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WATER MANAGEMENT AND SEDIMENT CONTROL FOR URBANIZING AREAS

UNITED STATES DEPARTMENT OF AGRICULTURE.
SOIL CONSERVATION SERVICE
COLUMBUS, OHIO

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I. GENERAL

Purpose

The purpose of this handbook is to provide information on water management and minimizing erosion and sediment on land undergoing development in urbanizing areas. The handbook pertains to soil, water and plant conservation and their relationships in upgrading the quality of the environment. The handbook has been prepared by the Soil Conservation Service (SCS) in working with Soil and Water Conservation Districts (hereafter referred to as Districts). This material may be used by property owners, land developers, local government agencies, consulting firms and others who share this interest.

The standards and specifications listed in this handbook are to provide criteria for the design, installation, and maintenance of water management and sediment control practices. Those responsible for design of these practices should evaluate the conditions existing on a particular site and determine if the minimum criteria contained in these standards are adequate or if more stringent criteria should be used.

Scope and Authority

The recommendations in the handbook apply to urbanizing lands where housing, industrial, institutional, recreational and highway developments are occurring or are being planned for those uses.

Recommendations are somewhat generalized due to wide variations in climate, topography, geology, soils and plant requirements. Feasible ways to handle water management and to minimize erosion and sediment in the State are varied and complex.

The SCS working through Districts, has broad authority to help people solve problems on soil, water and related resources. There may be times, however, when these problems or related conditions may need to be referred to outside groups for consultive or corrective measures. Any technical assistance given by SCS personnel must conform with established policies and procedures.

Kinds of assistance usually given to Districts in urban areas by SCS fall into three broad phases:

1. Assisting local groups or communities in the development of comprehensive or specific resource plans.

2. Installing soil, water, and plant conservation measures before or during construction.

3. Preparing maintenance programs for treatment measures.

Working relationships in urban areas of a District may be augmented by updating the memorandum of understanding between the District Supervisors and the SCS. The District may also enter into a memorandum of understanding with local planning commissions or other authorized agencies covering technical assistance in erosion and sediment control.

WATER MANAGEMENT AND SEDIMENT PROBLEMS ASSOCIATED WITH URBAN DEVELOPMENTS

The urbanizing process is such that many people may be adversely affected from small areas of land undergoing development. Unplanned water disposal and uncontrolled erosion and sediment from these areas may cause considerable economic damage to individuals and society in general. Stream pollution and damages to public facilities and private homes are among many examples.

Problems associated with urban developments include:

1. A large increase of areas exposed to soil erosion and runoff.

2. Increased volumes of runoff, soil movement, sediment, and peak flows caused by:

    a. Removal of natural plant cover.

    b. An increase of impervious surface areas due to construction of streets, buildings, sidewalks, and parking areas.

    c. Changes in drainage areas caused by grading operations, diversions and streets.

    d. Changes in volume and duration of water concentrations caused by altering steepness, distance, and surface roughness.

e. Reduction of water intake of soils from compaction by construction equipment. Compacted soils often reduce moisture infiltration rates from 1/16 to 1/20 of the original rate.

f. Prolonged exposure of unprotected sites and service areas to adverse weather conditions.

3. Altering groundwater regime that may adversely affect drainage systems, slope stability, survival of existing vegetation and establishment of new plants.

4. Creation of new south and west land exposure that may hinder plant growth.

5. Exposing subsurface materials that are too rocky, too acid, or otherwise unfavorable for establishing plants.

6. Encroachment on the floodplains by the construction of new buildings, land fills and other obstructions in the floodway.

7. Poor scheduling of construction and development activities.

II. RESOURCE PLANNING IN URBANIZING AREAS

Broad Resource Planning

Effective solutions to urban water management and sediment problems begin with planning. Broad resource plans can guide and control urban growth preventing wasteful and haphazard developments.

Districts and the SCS can give technical resource data and information that will serve as a basis for decision making by local authorities to fulfill the objectives established by broad plans. These objectives may include reserving best agricultural areas for cropland; maintaining an economic agricultural base; protecting historical, scenic and natural beauty areas; providing for open spaces and parks; developing attractive residential, institutional and industrial areas; and using floodplains and other problem areas for recreation and conservation uses.

Development of Plans

As more specific plans, such as subdivision plans, are developed for smaller increments of the broad region, SCS can furnish more detailed information and interpretations. This information will help determine the suitability of the site for the kind of development to be made. It will also help in planning and treating these lands to greatly reduce erosion and sediment problems during construction.

Certain basic data need to be assembled before adequate technical information and interpretations can be provided for a subdivision or other type of specific plan. These data consist primarily of:

Geography of the Area

Conditions of proposed project areas need to be examined early in the planning stages. These conditions include location, accessibility, present land use, size of proposed tract, topography, drainage pattern, geology, hydrology, soils, vegetation and climate. Such information is obtained from on-site examinations and existing technical reports, maps, records and other documented material usually available from local sources.

Study of Soils in the Area

Soils information, interpretations and data are basic to any urban development. These studies provide an understanding of the capabilities and general limitations of the site.

They point out the feasibility of planned land uses, economic considerations and conservation requirements of the site.

Principles for Effective Water Management and Sediment Control

Based upon data and information described above, planning assistance during the development of the plan may include the following phases:

Water management and sediment control provisions should be incorporated in the planning stage for most effective application in the construction stage of development.

Practical combinations of the following soil and water conservation practices will provide effective water management and sediment control when skillfully planned and applied.

1. The development plan should be fitted to the topography and soils so as to create the least erosion potential and preserve natural beauty by planning water disposal, road layout, and open spaces before development.

2. Areas with severe unalterable limitations such as floodplains, steep areas, and unstable soils be delineated for appropriate open space uses.

3. The smallest practical area of land should be exposed at any one time during development.

4. When the land is exposed during development, the exposure should be kept to the shortest practical period of time.

5. Temporary vegetation and/or mulching should be used to protect critical areas exposed during development.

6. Sediment basins (debris basins, desilting basins, or silt traps) should be installed and maintained to remove sediment from runoff waters from land undergoing development.

7. Terraces, diversions, and grassed waterways should be installed and maintained as water disposal systems to further control water and sediment in areas being developed.

8. Tile systems and other practices for drainage should be installed and maintained as soon as possible in land undergoing development.

9. The permanent vegetation, including use of sod, and structures should be installed and maintained as soon as practical in the development.

Predicting Soil Losses

Planners can estimate soil losses from construction sites by using the Universal Soil Loss Equation.

Predictions of soil losses in areas to be developed is directly related to resource planning. The predictions will influence the degree of planning and treatment required for proper control of erosion and sediment. Predicted soil losses may also create an awareness among developers, local government agencies and others of the urgent need to install conservation measures concurrent with construction.

(Refer to Appendix A for instructions and examples on how the Universal Soil Loss Equation is used for this purpose.)

Erosion and Sediment Control Ordinances

Local ordinances dealing with erosion and sediment control enhance and implement resource planning and development in areas that are to be urbanized. The SCS does not, in any way, participate in the enactment or enforcement of ordinances. This is strictly the responsibility of local government agencies and officials. At the request of local Districts, the SCS may furnish any available technical information or data that may be useful to authorized local government agencies.

Ordinances for control of erosion and sediment in urban developments usually contain several of the following provisions:

1. Developers must furnish local authorities with preliminary subdivision plans and extension of previous plans for approval. These plans must include erosion and sediment control measures.

2. Permits are required for any degree of grading and removal of earth on any property ot be developed. Grading needs to be in harmony with the general purpose and intent of zoning regulations and conservation programs of the area.

3. Disturbed areas must be covered with vegetation or mulch as soon as initial grading is completed. Controlled storm drainage systems must supplement vegetative cover. These control measures need to be applied within a prescribed time limit.

4. Design standards governing layout and construction of subdivisions, storm drainage plans, utilities, sewage disposal systems and slope limits must be approved. Treatment measures and design criteria for controlling runoff, erosion and sediment are also required.

5. Posting of a performance bond by contractors to help insure the installation of soil erosion control measures and protection of other resources.

STANDARD AND SPECIFICATIONS FOR CRITICAL AREA STABILIZATION (With Temporary Seedings)

STANDARD

Definition

Stabilizing silt producing areas by establishing short-term vegetative cover.

Purpose

To stabilize the area and reduce damages from sediment and runoff to downstream areas.

Criteria

Seeding should be applied the same day that operations are completed that produce the disturbed areas. On areas such as rough grading where additional work is not scheduled for a period of three (3) weeks or longer, the area should be seeded immediately. In areas where unanticipated delays are encountered, the areas should be seeded as soon as the delay is recognized.

All constructed slopes and cuts should be seeded as each vertical interval of no more than ten (10) feet is completed.

The plant species should be selected on the basis of quick germination and growth.

Fertilizer, lime, seedbed preparation, seed coverage, mulch, and irrigation should be used as necessary to promote quick plant growth.

SPECIFICATIONS

I. Site Preparation

A. Grade as needed and feasible to permit use of conventional equipment for seedbed preparation, seeding, mulch application and anchoring.

B. Install needed erosion control practices such as diversions, temporary waterways for diversion outlets, and desilting basins. (See Standard and Specifications for above practices in this Handbook).

II. Seedbed Preparation

A. Lime (In lieu of a soil test) on acid soil and subsoil - 100 pounds per 1000 square feet or 2 tons per acre of agricultural ground limestone or equivalent. For best results make a soil test.

B. Fertilizer (In lieu of a soil test). Apply 12-15 pounds per 1000 square feet or 500-600 pounds per acre of 10-10-10 or 12-12-12 analysis. For best results make a soil test.

C. Work lime and fertilizer into the soil with a disk harrow, springtooth harrow, or other suitable field equipment to a depth of 2 inches. On sloping land the final operation should be on the contour.

III. Seeding

A. Select a species or mixture from Table 1.

B. Apply seed uniformly with a cyclone seeder, drill, cultipacker seeder, or hydroseeder (slurry may include seed and fertilizer) preferably on a firm, moist seedbed. Cover to a depth of 1/4 to 1/2 inch.

C. Where feasible, except when a cultipacker type seeder is used, the seedbed should be firmed following seeding operations with a cultipacker, roller, or light drag. On sloping land seeding operations should be on the contour wherever possible.

IV. Mulching

A. Mulch should be applied to protect soil and provide a better environment for plant growth.

1. Mulch materials should be unweathered small grain straw (preferably wheat) and should be applied immediately after seeding at the rate of 2 tons per acre or 100 pounds (2-3 bales) per 1000 square feet.

2. Spread mulch uniformly by hand or mechanically so that the soil surface is covered.

3. Mulch anchoring methods.

   a. Mulch anchoring tool - Use a mulch anchoring wool with a series of flat, notched discs that punch and anchor the mulch material into the soil.

   b. Asphalt Mulch Tie-Down

      (1) Liquid asphalt - rapid curing (R.C. 70, 250, or 800) or medium curing (M.C. 250 or 800). Apply 0.04 gallons per square yard or 200 gallons per acre. Liquid asphalt, since it is cut back with a kerosene-like product, can be applied during freezing weather.

      (2) Emulsified asphalt - rapid setting (R.S. 1 or 2) medium setting (M.S. 2) or slow setting (S.S 1). Apply 0.03 gallons per square yard or 160 gallons per acre. Emulsified asphalt contains approximately 50% water, therefore, it cannot be applied during freezing weather.

   c. Mulch Nettings - staple light-weight paper, jute, cotton or plastic nettings to the soil surface according to manufacturer's recommendations. Use in areas of water concentration to hold mulch in place.

V. Irrigation

If soil moisture is deficient, supply new seedings with adequate water for plant growth until they are firmly established. This is especially true when seedings are made late in planting season, in abnormally dry or hot seasons, or on adverse sites.

TABLE I

Temporary Seedings and Seeding Dates

Kind of Seed 1/	Seeding Dates 2/	Per 1000 Sq.Ft.	Per Acre
Oats	March 1 - June 15	3 pounds	4 bushel
Oats and		2 pounds	2 bushel
Sudangrass	June 16 - Aug. 15	2 pounds	2 bushel
Rye or Wheat	Aug. 16 - Nov. 1	3 pounds	2 bushel

After November 1 use Mulch only.

1/ Other seed species may be substituted for the above, check with the local SCS office for recommendations.

2/ These seeding dates are ideal. With the use of mulch and irrigation, seedings could be made any time from March to September.

STANDARD AND SPECIFICATIONS FOR CRITICAL AREA STABILIZATION (With Permanent Seedings)

STANDARD

Definition

Stabilizing silt-producing areas by establishing long-term stands of vegetations.

Purpose

To stabilize the area and reduce damages from sediment and runoff to downstream areas.

Conditions Where Practice Applies

Graded and cleared areas subject to erosion where a permanent, long-lived vegetative cover is needed, on areas where final grading on steep slopes has been completed, and on diversions, grassed waterways, and desilting basins. (See Standard and Specifications for above practices in this Handbook).

SPECIFICATIONS

Vegetation cannot be expected to provide an erosion control cover and prevent soil slippage on a soil that is not stable due to its structure, water movement or excessive slope.

Minimum soil conditions needed for the establishment and maintenance of a long-lived vegetativer cover:

A. Enough fine-grained materials (over 25% silt and clay) to provide the capacity to hold at least a moderate amount of available moisture.

   Excessively porous sands which have moisture supplies consistently too low for growth of plants cannot be maintained in good cover regardless of other soil factors.

B. Sufficient pore space to permit adequate root penetration.

C. No concentrations of toxic elements.

I. Site Preparation

A. Stockpile topsoil to apply to sites that are otherwise unsuited for establishing vegetation.

B. Grade as needed and feasible to permit the use of conventional equipment for seedbed preparation, seeding, mulch application and anchoring, and maintenance. After grading operation spread topsoil where needed.

C. Install needed erosion control practices such as diversions, grassed waterways for diversion outlets, and desilting basins. (See Standards and Specifications for above practices in this Handbook).

II. Seedbed Preparation

A. Lime (In lieu of a soil test) on acid soil and subsoil - 100 pounds per 1000 square feet or 2 tons per acre of agricultural ground limestone or equivalent. For best results make a soil test.

B. Fertilizer (In lieu of a soil test) Apply 25 pounds per 1000 square feet or 1000 pounds per acre of 10-10-10 or 12-12-12 analysis. For best results make a soil test.

C. Work lime and fertilizer into the soil with a disk harrow, springtooth harrow, or other suitable field equipment to a depth of 3 inches. On sloping land the final operation should be on the contour.

III. Seeding

A. Select a species or mixture from Table 1.

B. Apply seed uniformly with a cyclone seeder, drill, cultipacker seeder, or hydro-seeder (slurry may include seed and fertilizer) on a firm, moist seedbed. Cover to a depth of 1/4 to 1/2 inch.

C. Where feasible, except when a cultipacker type seeder is used, the seedbed should be firmed following seeding operations with a cultipacker, roller, or light drag. On sloping land, seeding operations should be on the contour where feasible.

IV. Mulching

A. Mulch materials should be unweathered small grain straw (Preferably wheat) and should be applied immediately after seeding at the rate of 2 tons per acre or 100 pounds (2-3 bales) per 1000 square feet.

B. Mulch Anchoring Methods

1. Mulch anchoring tool - Use a mulch anchoring tool with a series of flat, notched disc that punch and anchor the mulch material into the soil.

2. Asphalt Mulch Tie-down

a. Liquid asphalt - rapid curing (R.C. 70, 250, or 800) or medium curing (M.C. 250, 800). Apply 0.04 gallons per square yard or 200 gallons per acre. Liquid asphalt, since it is cut back with a kerosene-like product, can be applied during freezing weather.

b. Emulsified asphalt - rapid setting (R.S. 1 or 2) medium setting (M.S. 2) or slow setting (S.S. 1). Apply 0.03 gallons per square yard or 160 gallons per acre. Emulsified asphalt contains approximately 50% water, therefore it cannot be applied during freezing weather.

3. Mulch Nettings - Staple lightweight paper, jute, cotton or plastic nettings to the soil surface according to manufacturer's recommendations. Use in areas of water concentration to hold mulch in place.

V. Maintenance

Maintenance is a vital factor in maintaining an adequate vegetative erosion control cover. See Table 2.

A. Irrigation - If soil moisture is deficient, supply new seedings with adequate water for plant growth until they are firmly established. This is especially true when seedings are made late in the planting season, in abnormally dry and hot seasons, or on adverse sites.

B. Repairs - Inspect all seeded areas for failures and make necessary repairs, replacements, reseedings, and re-mulching within the planting season, if possible.

1. If stand is inadequate, overseed, fertilize, using half of rates originally applied, and mulch.

2. If stand is over 60% damaged, reestablish following original lime, fertilizer, seedbed preparation, seeding recommendations, and mulching recommendations.

TABLE I

Kind of Seed 1/	Seeding Dates 2/	Per 1000 Sq.Ft.	Per Acre
I. Permanent Seeding			
A. Creeping Red Fescue and	Mar-May, Aug-Sep	1/2 pound	20 pounds
Domestic Ryegrass and		1/4 pound	10 pounds
Kentucky Bluegrass		1/4 pound	10 pounds
B. Tall Fescue	Mar-May, Aug-Sep	1 pound	40 pounds
C. Creeping Red Fescue and	Mar-May, Aug-Sep	1/2 pound	20 pounds
Tall Fescue		1/2 pound	20 pounds
II. Special Area Seedings			
A. Steep Banks or Cuts			
1. Tall Fescue	Mar-May, Aug-Sep	1 pound	40 pounds
2. Crownvetch and	March-May	1/4 pound	10 pounds
Tall Fescue		1/2 pound	20 pounds
B. Waterways and Road Ditches			
1. Tall Fescue	May-May, Aug-Sep	1 pound	40 pounds

1/ Other seed species may be substituted for these mixtures. Check with local SCS office for recommendations.

2/ These seeding dates are ideal. With the use of mulch and irrigation, seedings could be made any time from March to September.

TABLE II

Maintenance Fertilization and Mowing for Permanent Seeding

Mixture	Formula	Fertilizer Rate Lbs/Ac	Fertilizer Rate Lbs/1000 Sq. Ft.	Time	Mowing
I. A. Creeping Red Fescue, Domestic Ryegrass, Kentucky Bluegrass	10-10-10	500	12	Fall. Yearly or as needed	Not closer than 3"
I. B. Tall Fescue	10-10-10	500	12	Fall. Yearly or as needed	Not closer than 4"
I. C. Creeping Red Fescue	10-10-10	500	12	Fall. Yearly or as needed	Not closer than 4"
II. A. 2 Crownvetch	0-20-20	400	10	Spring. Year following establishment and every 4-7 years thereafter	Do not mow.
II. A. 1, II. B. 1. Tall Fescue	10-10-10	500	12	Fall. Yearly or as needed	Not closer than 4"

USDA, Soil Conservation Service
Columbus, Ohio

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STANDARD AND SPECIFICATIONS FOR CRITICAL AREA STABILIZATION (Using Ground Covers, Vines, Shrubs, and Trees)

STANDARD

Definition

Planting permanent vegetation such as ground covers, vines, shrubs, and trees on critical areas.

Purpose

To stabilize the area; reduce damages from sediment and runoff to downstream areas; to enhance natural beauty.

Conditions Where Practice Applies

Graded or cleared areas subject to erosion, where a permanent, long-lived vegetative cover other than turf is desired.

SPECIFICATIONS

Listed are some plants known to be suitable for soil erosion control and possessing aesthetic value. This list is neither inclusive or exclusive. The list includes plants which establish easily on difficult sites, as well as plants that will require some site improvement before they grow satisfactorily.

These plants cannot be expected to provide an erosion control cover and prevent soil slippage on a soil that is not stable due to its structure, water movement, or excessive slope.

Ground covers are not necessarily low-maintenance plants, although some of them are. In general, they are more difficult to establish than turf. Plants included in this list respond favorably to careful treatment during the period of establishment.

I. Planting Time:

A. Early spring. This allows for the maximum root and top development to check soil erosion and allow the plant to become established before winter.

II. Soil Preparation:

A. For short slopes, small areas, and mass plantings of close spacing apply a commercial granular fertilizer, such as 5-10-10, and organic supplement, such as composted cow manure, peat, or well-rotted sawdust, and work into the soil prior to planting. Fertilizer rate - 30-50 pounds per 1000 square feet. The organic material needed will depend upon the soil and plant being used. Plants such as pachysandra require a high rate of organic material, about a 2-inch layer worked into the root zone. Depending on the type and steepness of slope, the depth of soil preparation will vary from 4 to 6 inches.

B. For steep slopes and large area plantings, working up the entire planting area would be impactical and would probably induce erosion. Center hole planting, a hole dug for each plant, would be more desirable. If the soil on the slope is poorly suited to the species being planted, incorporate organic material into the planting hole. Whether organic material is needed or not, fertilize each plant at the rate of one ounce per plant of a complete fertilizer such as 10-10-10. Mix fertilizer with soil below the roots of the plants, or place slow release pellet or packet in bottom of planting hole.

C. Another alternative is to add to the planting hole a sandy loam soil mixed with peat, composted cow manure, or well-rotted sawdust at a rate of 1:1 or 2:1.

D. The entire planted slope should be covered with a protective mulch, such as straw, wood chips, or wood pulp fiber, to conserve moisture and control soil erosion. Weeds should be controlled.

E. Where erosion hazard is very high, jute matting or fiber glass matting stapled to the slope will provide excellent soil erosion control.

III. Establishment:

A. Some Watering, weeding, remulching, and fertilizing may be required of a new planting during the period of establishment. Cultivation is not recommended. This will encourage soil erosion and cause root injury. Competing weeds should be controlled.

B. If a controlled release fertilizer was used at the time of planting, additional fertilizing will not be necessary for several years. Otherwise, fertilize plantings the spring of the second growing season and thereafter as needed, using 2 to 3 pounds per 100 square feet of a granulated commercial fertilizer such as 5-10-10.

USDA, Soil Conservation Service
Columbus, Ohio

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CRITICAL AREA STABILIZATION

(WITH GROUND COVERS, VINES, SHRUBS AND TREES)

Ground Cover Plants	Winter Aspect Evergreen Semi-Evergreen Herbaceous	Soil Site Conditions	Light Prefers Tolerates Sun	Shade	Range of Height Inches	Spread Rapid Medium Slow	Spacing Between Plants (In.)	Time to Form Cover (Years)	Area (Size Limitations) Large Over 500 sq. ft.	Bloom Distinct Indistinct Color	NOTES
TRAILING PLANTS											
Japanese Spurge (Pachysandra terminalis	E	Well drained to excessively drained. Neutral to medium acidity		P	6-8	M	6-8	2	None	I White	Forms thick carpet of yellow-green foliage, even under pines. On open locations leaves may burn in winter, spreads by underground stems.
Baltic English Ivy (Hedera helix baltica)	E	Well drained.	T	P	6-8	M-R	18-24	2	Large	I White	Forms dense green mat with trailing root stems. Stands severe cold better than English Ivy. Easy to cultivate.
Common Periwinkle (Vinca minor)	E	Well drained. Neutral to medium acidity.	T	P	5-6	R	12-18	1-2	None	D Blue to White	Forms glossy green long lived cover requiring little maintenance. Easy to establish. Excellent soil stabilizer.
Bearberry (Arctostaphylos uva-ursi)	E	Excessively drained. Slightly acid	P	T	2-4	S	12-24	2-3	None	I White	Forms attractive thick prostrate mat of trailing stems. Established from potted plants only. Salt tolerant. Excellent sand stabilizer.
Littleleaf cotoneaster (Cotoneaster dammeri radicans)	E	Moderately well to well drained.	P	-	10-15	M	12-18	2	None	I White	A prostrate shrub with long, trailing, often rooting branches. Forms tough cover. Will cover rocky slopes.
Purpleleaf Wintercreeper (Euonymus fortunei colorata)	E	Well drained.	T	P	12-24	Slow	24"	2-3	None	I If at all	Turns purplish red in fall and remains all winter.
Vines	Deciduous				Range of Hgt. (In.) (Ft.)						
Hall's Honeysuckle (Lonicera japonica halliona)	S-E	Well drained	P	T	12-36*	M	36"	2	Large	D White	An excellent vine for all purposes.
Cross-Vine (Bignonia caprealata)	E	Well drained	P		12-36	M	36"	2	None	D Orange-Red	Southern Ohio only (Columbus and south).
Fiveleaf Akebia (Akebia quinata)	S-E	Moderately well drained	T	P	6-8 / 15+	R	2-3	2	Large Areas	D Red	A vigorously growing twiner with rich dark green, clean foliage, somewhat like honeysuckle. Covers steep slopes. Will climb. *
EVERGREEN SHRUBS											
Needle Evergreen Up to 3 ft.						Growth	(Feet)				
Sargent Juniper (Juniperus chinensis sargenti)		Moderately well to somewhat excessively drained. Slightly acid	P	-		M	3-4	2-3			A low prostrate, creeping shrub with steel-blue foliage. Forms dense mat. Tolerates salt spray.
Canada Yew (Taxus canadensis)		Moderately well drained. Medium Acid.	T	P		S	2-3	2-3			A very hardy low spreading, straggling, long lived shrub. Showy autumn scarlet fruit.
Broadleaf Evergreen Up to 3 ft.											
Bearberry Cotoneaster (Cotoneaster dammeri)		Well drained.	P	T		M	2-3	2-3			A prostrate shrub with long, trailing, often rooting branches. Red berries. Covers steep rocky slopes. Susceptible to fire blight. Do not use bare root stock.
Needle Evergreen 4 to 6 ft.											
Pfitzer's Juniper (Juniperus chinensis pfitzeriana)		Well drained.	P	T		R	3-4	2			A broad often flat topped, wide-spreading shrub. Long lived and very hardy.
Japanese Yew (Taxus cuspidata densa)		Well drained.	T	P		M	3	2-3			A handsome, compact, low shrub with dark green foliage and red fleshy berries in autumn. Long lived.
DECIDUOUS SHRUBS Up to 3 ft.											
Arnold Dwarf Forsythia (Forsythia arnoldi)		Well drained.	P	-		R	2-3	2		I Yellow	A true dwarf shrub with drooping branches that root as they touch the ground
Fragrant Sumac (Rhus Aromatica)		Well drained. Medium acid.	P	-		R	2-3	2		I Yellow	A low dense irregular spreading shrub. Forms colonies. Brilliant autumn foliage and fruit.
Hardhack Spirea Spirea tomentosa)		Somewhat poorly drained to well drained.	P	-		R	2-3	2		D Rose	An upright clump type shrub with rooting branches. Good for naturalizing and clump plantings.
Black Chokeberry (Aronia melanocarpa)		Moderately well to well drained. Medium acidity.	T	T		M	2-3	2-3		D White	A suckering shrub of loose habit with upright stems. Good woodland border plant. Black berries and red foliage in autumn.
Siebold Forsythia 4 to 6 ft. (Forsythia suspensa sieboldi)		Well drained.	P	-		R	3-4	2		D Yellow	A vigorous shrub with pendulous, spreading rooting branches.
Bristly locust (Robinia hispida)		Well drained.	P	-		R	3-4	2		D Purple	A much branched thicket forming shrub. Spreads vigorously by under-ground suckers. Give plenty of space. Excellent soil stabilizer.

* Will grow to 30' with support.

* May be difficult to control

Ground Cover Plants	Winter Aspect Evergreen Semi-Evergreen Herbaceous	Soil Site Conditions	Light Prefers Tolerates Sun	Shade	Range of Height Inches	Spread Rapid Medium Slow	Spacing Between Plants (In.)	Time to Form Cover (Yrs.)	Area (Size Limitations) Large Over 500 sq. ft.	Bloom Distinct Indistinct Color	NOTES
DECIDUOUS SHRUBS 4 to 6 ft.											
Black Raspberry (Rubus occidentalis)		Moderately well to well drained.	P			M	5'	2	Large	D White	Useful in large areas and waste places. Will tip layer. Fiberous root system. Wildlife uses berries.
Snowberry (Symphoricarpos albus)		Somewhat poorly drained to well drained.	T	P		R	2-3	2		D White	A slender, loosely ascending shrub with showy white autumn fruit.
Coralberry (Symphoricarpos orbiculatus)		Somewhat poorly drained to well drained.	T	T		R	2-3	2		I Pink	A low, freely suckering shrub with slender, upright, spreading branches. A clump former. Showy coral fruit, excellent soil stabilizer.
Billiard Spirea (Spirea billiardi)		Well drained	T	T		R	2-3	2		D Rose	An erect shrub which increases by underground stems to form a dense mass.
7 to 10 ft.											
Gray Dogwood (Cornus racemosa)		Poorly drained to well drained.	P	T		R	3-4	2		I White	Bushy, spreading, stoloniferous shrub. Suckers freely. Colony former.
Japanese Barberry (Berberis thunbergi		Moderately well to well drained.	P	T		S	2-3	2-3		I Yellow	A very twiggy, compact shrub with red autumn foliage and berries. Forms a deterrent to traffic. Thorns toxic to some people.
Red Chokeberry (Aronia arbutifolia		Somewhat poorly drained to well drained.	P	T		M	3-4	2-3		D White	A dependable shrub, open branches and suckering. Showy red fruit, and foliage in autumn.
Ninebark (Physocarpus opulifolius)		Well drained.	P	-		R	3-4	2		D White	A vigorous shrub with coarse twiggy recurving branches. Very hardy. Use in large plantings.
Regel Privet (Ligustrum obtusifolium regelianum)		Moderately well to well drained.	P	-		M	3-4	2-3		I White	A low growing hardy shrub with distinctive horizontal branching. Make attractive contour row plantings.
11 to 15+ ft.											
Tatarian Honeysuckle (Lonicera tatarica		Well drained.	P	T		R	3-4	2		D White	A refined upright shrub free of disease and insects. Good for clump or contour row plantings.
Staghorn Sumac (Rhus typhina)		Well drained.	P	-		M	4-5	2-3		I Yellow	A staggling shrub with a flattish crown. Brilliant scarlet autumn foliage and fruit. Colony former for large areas.
Shining Sumac (Rhus copallina)		Well drained	P	-		M	4-5	2-3		I Yellow	One of the most ornamental sumacs with brilliant red fall color. Colony former for large areas.
Cardinal Autumn Olive (Elaeagnus umbellata)		Moderately well to well drained.	P	-		R	4-5	2		I Yellow	A very hardy spreading shrub with silvery foliage and abundant red fruit. For large areas.
Amur Privet (Ligustrum amurense)		Moderately well to well drained.	P	-		R	4-5	2		I White	A dense, pyramidal, upright shrub with stiffly upright, lateral twigs. Considerably hardier than California privet. Large areas.
Arrow-Wood (Viburnum dentatum)		Poorly drained to well drained.	P	T		R	4-5	2		D White	A vigorous bush, upright shrub which spreads from numerous basal shoots. Large areas - mass plantings.
TREES								Spacing Between Plants (Ft.)	Height Range (Ft.)		
Washington Hawthorn (Crataegus phaenopyrum)	D	Moderately well to well drained.				M		5-9	30		Dense twiggy upright growth. Profuse red flowers. Brilliant autumn foliage. Red fruit lasts all winter.
Tree of Heaven (Ailanthus altissima)	D	Moderately well to well drained.				R		5-9	50+		Extreme rapid grower. Thrives under extremely adverse conditions. Will spread.
European Black Alder (Alnus glutinosa)	D	Poorly drained to well drained.				R		5-9	50+		A small tree with spreading branches and a symmetrical ovoid to oblong top.
Japanese Larch (Larix leptolepis)	D	Moderately well to well drained.				R		5-9	50+		A graceful deciduous conifer with short horizontal branches. Quickly lays down a ground cover of needles.
Scotch Pine (Pinus sylvestris)	E	Somewhat poorly drained to well drained.				R		5-9	50+		Pyramidal when young, irregular shape when older. A very rugged conifer.
Virginia Pine (Pinus virginiana)	E	Moderately well to well drained.				R		5-9	50±		A rugged conifer of open habit and sparse branching. A good litter producer on poor soils.
Common Juniper (Juniperus communis)	E	Neutral to moderately alkaline. Moderately well to well drained.				S		4-6	25+		A small conifer of pyramidal habit. A variable species.
Eastern Red Cedar (Juniperus virginiana)	E	Moderately well to well drained. Neutral to moderately alkaline.				S		5-7	50±		A densely pyramidal, often columnar conifer with scale-like foliage. Female plant bears blue fruit. A long lived tree in full sun.

STANDARD AND SPECIFICATIONS FOR CRITICAL AREA STABILIZATION (With Mulching Only)

STANDARD

Definition

Stabilizing silt-producing areas by applying plant residues or other suitable materials, not produced on the site, to the surface of the soil.

Purpose

To reduce runoff and erosion.

Conditions Where Practice Applies

Graded or cleared areas which are subject to erosion for six months or less; where seedings may not have a suitable growing season to produce an erosion retardant cover, but which can be stabilized with mulch cover.

SPECIFICATIONS

I. Site Preparation

A. Grade as needed and feasible to permit use of conventional equipment for applying and anchoring mulch.

B. Install needed erosion control practices such as diversions, temporary waterways for diversion outlets, and desilting basins.

II. Mulching

A. Mulch materials should be unweathered small grain straw (Preferably wheat) and should be applied at the rate of 2 tons per acre or 100 pounds (2-3 bales) per 1000 square feet.

B. Spread mulch uniformly by hand or mechanically so the soil is surface covered.

C. Mulch Anchoring should be accomplished immediately after placement to minimize loss by wind and water.

D. Mulch Anchoring Methods.

1. Mulch anchoring tool - Use a mulch anchoring tool with a series of flat, notched discs that punch and anchor the mulch material into the soil.

2. Asphalt mulch tie-down

    a. Liquid asphalt - Rapid curing (R.C. 70, 250, or 800) or medium curing (M.C. 250 or 800). Apply 0.04 gallons per square yard or 200 gallons per acre. Liquid asphalt, since it is cut back with a kerosene like product, can be applied during freezing weather.

    b. Emulsified asphalt - Rapid setting (R.S. 1 or 2), medium setting (M.S. 2) or slow setting (S.S. 1). Apply 0.03 gallons per square yard or 160 gallons per acre. Emulsified asphalt contains approximately 50% water, therefore it cannot be applied during freezing weather.

3. Mulch Nettings - Staple lightweight paper, jute, cotton, or plastic nettings to the soil surface according to manufacturers recommendations. Use in areas of water concentration to hold mulch in place.

STANDARD AND SPECIFICATIONS FOR CRITICAL AREA STABILIZATION (With Sod)

STANDARD

Definition

Stabilizing silt-producing areas with grass sod.

Purpose

To stabilize the area, to reduce damages from sediment and runoff to downstream areas.

Conditions Where Practice Applies

Graded areas subject to erosion and water concentration where an immediate vegetative cover is desired and feasible.

SPECIFICATIONS

I. Site Preparation

A. Stockpile topsoil to apply to sites that are otherwise unsuited for establishing vegetation.

B. Grade as needed and feasible to permit the use of conventional equipment for sodbed preparation. After grading operation spread topsoil where needed.

II. Sodbed Preparation

A. Lime (In lieu of a soil test) on acid soil and subsoil apply 100 pounds per 1000 square feet or 2 tons per acre of agricultural ground limestone or equivalent. For best results make a soil test.

B. Fertilizer (In lieu of a soil test). Apply 25 pounds per 1000 square feet or 1000 pounds per acre of 10-10-10 or 12-12-12 analysis. For best results make a soil test.

C. Work lime and fertilizer into the soil with a disk harrow, springtooth harrow, or other suitable field equipment to a depth of 3 inches.

D. Prior to sodding, the soil surface should be cleared of all trash, debris, and stones larger than 1 1/2 inches in diameter, and of all roots, brush, wire, and other objects that would interfere with the placing of the sod.

E. After the lime and fertilizer has been applied and just prior to the laying of the sod, the soil in the area to be sodded should be loosed to a depth of one inch. The soil should be thoroughly dampened immediately after the sod is laid if it is not already in a moist condition.

III. Cutting and Handling of Sod

A. The sod should consist of strips of live, vigorously growing grass such as bluegrass or tall fescue. The sod should be free of noxious and secondary noxious weeds and should be obtained from good, solid, thick growing stands. The sod should be cut and transferred to the job in as large continuous pieces as will hold together and are practical to handle.

The sod should be cut with smooth clean edges and square ends to facilitate laying and fitting. The sod should be cut to a uniform thickness of not less than two inches measured from the crown of the plants to the bottom of the sod strips for all grasses except bluegrass. Bluegrass sod should be cut to a uniform thickness of not less than one and one-half inch.

The sod should be mowed to a height of not less than two inches nor more than four inches prior to cutting.

The sod should be kept moist and covered during hauling and preparation for placement on the sodbed.

IV. Placing the Sod

A. No sod should be placed when the temperature is below 32°F. No frozen sod should be placed nor should any sod be placed on frozen soil. When sod is placed between the periods of June 1 and October 1, and between the periods December 1 and March 1, it should be covered immediately with a uniform layer of straw mulch approximately one-half inch thick or so the green sod is barely visible through the mulch.

Sod should be carefully placed and pressed together so it will be continuous without any voids between the pieces. Joints between the ends of strips should be staggered. The edge of the sod at the outer edges of all gutters shall be sufficiently deep so that the surface water will flow over and onto the top of the sod.

On gutter and channel sodding the sod should be carefully placed in rows or strips at right angles to the centerline of the channel (i.e. at right angles to the direction of flow). On steep graded channels each strip of sod should be staked with at least two stakes not more than eighteen inches apart. The stakes should be wood and should be approximately 1/2 X 3/4" X 12". They should be driven flush with the top of the sod and with the flat side against the slope.

On slopes three to one, or steeper, and where drainage into a sod gutter or channel is one half acre or larger, two inch poultry netting should be staked in place on the surface of the sod. The netting and sod should be staked with at least two stakes not more than eighteen inches apart.

The stakes should be wood and should be approximately 1/2" X 3/4" X 24". They should be driven with the flat side against the slope and on an angle toward the slope. The netting should be stapled on the side of each stake within two inches of the top of the stake. The stake should then be driven flush with the top of the sod.

The sod should be tamped or rolled after placing and then watered. Watering should consist of a thorough soaking of the sod and of the sodbed to a depth of at least four inches. The sod should be maintained in a moist condition by watering for a period of thirty days.

Any areas disturbed so as to destroy present seedlings along the edge of the sodbed should be reseeded and mulched as specified in the permanent Seeding Standards and Specifications.

USDA, Soil Conservation Service
Columbus, Ohio

April 1972

STANDARD AND SPECIFICATIONS FOR WINDBREAKS FOR URBAN AREAS

STANDARD

Definition

A narrow belt of trees or shrubs established adjacent to urban homes or commercial buildings, or along streets, or in recreation areas.

Purpose

To protect soil resources, control snow deposition, prevent wind damage to urban buildings, beautify the landscape, and provide wildlife food and cover.

Conditions Where Practice Applies

To the windward of and a serviceable distance from:

a. Urban homes and commercial buildings.

b. Urban streets.

c. Urban recreation areas.

SPECIFICATIONS

A. Design the Windbreak

1. Number of tree rows needed: 3 is minimum without a shrub row; with 1 shrub row, 2 tree rows is required.

2. Directional orientation.

   a. Minimum: One-leg, straight-line, perpendicular to prevailing wind.

   b. Preferable: Two-leg, L-shaped (as viewed from above).

   Note: West and southwest winds are prevalent over most of Ohio; West and Northwest winter winds are considered most severe for northwest area of Ohio.

3. Distance between windbreak and near edge of protective zone:

   a. Not closer than: 75 feet.

   b. Optimum: 100-150 feet.

4. Spacing between rows:

   a. Not closer than: 10 feet

   b. Optimum: 14 feet.

5. Spacing in-the-row:

   a. Trees, narrow crowned: 5-6 feet apart.

   b. Trees, normal crowns: 10-12 feet apart.

   c. Shrubs: 2-6 feet apart.

6. Arrangement in-the-rows:

   a. Stagger seedlings with relation to seedlings in adjacent row.

7. Length of windbreak:

   a. Minimum: 150 feet, each leg.

   b. Optimum: Extend each leg 50-100 feet beyond last point needing protection.

8. Tree Species:

	Tolerance to Drainage and Acidity		
	Poorly to Somewhat Poorly Drained Sites	Moderately Well to Well Drained Sites	pH Range 1/
a. Arborvitae (*Thuja occidentalis*)	Yes	Yes	Medium acid to mildly alkaline
b. Eastern redcedar (*Juniperus virginiana*)	Limited	Yes	Medium acid to mildly alkaline
c. Austrian pine (*Pinus nigra*)	Yes	Yes	Slightly acid to mildly alkaline

	Tolerance to Drainage and Acidity		
	Poorly to Somewhat Poorly Drained Sites	Moderately Well to Well Drained Sites	pH 1/ Range
d. Scotch pine (Pinus sylvestris)	No	Yes	Strongly acid to neutral
e. White pine * (Pinus strobus)	Yes	Yes	Medium acid to mildly alkaline
f. Norway spruce (Picea abies)	Yes	Yes	Strongly acid to neutral

* Best suited for leeward side

1/ Extremely acid	Below 4.5	Slightly acid	6.1 - 6.5
Very strongly acid	4.5 - 5.0	Neutral	6.6 - 7.3
Strongly acid	5.1 - 5.5	Mildly alkaline	7.4 - 7.8
Medium acid	5.6 - 6.0		

9. Shrub Species:

	Soil 1/ Drainage Tolerance	Effective 2/ Fruiting Season	Seasons 2/ Most Attractive
a. Autumn Olive (Elaeagnus umbellata)	MW to WD	F	Sp, F
b. Amur privet (Liqustrum amurense)	WD	F	Sp
c. Tatarian honeysuckle (Lonicera tatarica)	MW to WD	S	Sp, F
d. Multiflora rose * (Rosa multiflora)	MW to WD	W	Sp
e. Rugosa rose (Rosa rugosa)	WD	S	S
f. Medium purple willow (Salix purpurea)	VPD-MW	-	S
g. Common lilac (syringia vulgaris)	MW-WD	-	Sp

	Soil Drainage Tolerance 1/	Effective Fruiting Season 2/	Seasons Most Attractive 2/
h. Wayfaring tree (<u>Viburnum lantana</u>)	WD	F-W	F
i. Nannyberry (<u>Viburnum lentago</u>)	MW-WD	F-W	F
j. Flowering quince (<u>Chaenomeles japonica</u>)	MW-WD	W	Sp
k. Silky dogwood (<u>Cornus amonum</u>)	VPD-MW	S	Sp
l. American cranberrybush (<u>Viburnum trilobum</u>)	VPD-MW	S	F
m. Winged spindletree (<u>Euonymus alatus</u>)	WD	F	F
n. Forsythia (<u>Forsythia sp.</u>)	MW-WD	-	Sp

* Use in northcentral and northwestern Ohio only.

1/ VPD - Very poorly drained
SPD - Somewhat poorly drained
WD - Well drained
MW - Moderately well drained

2/ Sp - Spring
S - Summer
F - Fall
W - Winter

B. Order Planting Stock

1. Allow time for site preparation.

2. Order early to insure delivery.

C. Prepare the Site

Eliminate weed, grass, and sod growth prior to planting season.

D. Plant the Windbreak Stock

1. Keep stock cool and roots moist.

2. Open planting hole or slit deep enough and wide enough to accommodate roots.

3. Set main root vertical, slightly deeper than it was in nursery; spread branch roots loosely.

4. Close planting hole or slit, bottom to top, and press soil firmly against roots.

E. Protect and Maintain Windbreak

1. Cultivate or chemical-spray against weeds, grass, and other encroaching plants for at least two growing seasons.

2. Irrigate seedlings, as needed, during first summer.

3. Replace individual "drop-out" stock as needed during early years of windbreak life.

4. In subsequent years, before individual trees become crowded in the row, thin lightly as needed.

STANDARD AND SPECIFICATIONS FOR TOP SOILING

STANDARD

Definition

Obtaining topsoil from other places and spreading it over the area to be stablized.

Purpose

To provide a suitable soil medium for vegetation growth on areas where other measures will not produce or maintain a stand of desirable vegetation.

Conditions Where Practice Applies

This practice applies to sites where:

1. The texture of the exposed subsoil or present material is clay, silty clay, sand or loamy sand which is not suitable to produce adequate vegetative growth.

2. The soil material is so shallow that the rooting zone is not deep enough to support plants and furnish continuing supplies of moisture and plant food.

3. The soil to be vegetated contains material toxic to plant growth. (Coal blossom, aluminum, iron, extreme acidity, etc.)

SPECIFICATIONS

SECTION I - SUBSOIL PREPARATION (Where topsoil is to be added)

Note: This specification applies only if additional topsoil will be deposited over existing soil.

A. General: The areas to which these specifications apply and on which topsoil is to be spread shall be indicated on the drawings or as otherwise specificed.

B. Grading: Grades on the areas to be topsoiled which have been previously established in conformance with the drawings shall be maintained.

C. Liming: Where the subsoil is highly acid, Agricultural Ground Limestone, or its equivalent, shall be spread at the rate of 100 pounds per 1000 square feet. Liming material shall contain calcium and/or magnesium equal to not less than 90% calcium carbonate equivalent, and the material shall be sufficiently fine so that 95% will pass through a U. S. Standard No. 8 sieve and at least 40% shall pass through a U. S. Standard No. 100 sieve. Lime shall be distributed uniformly over the designated areas and worked into the soil with the use of a disk harrow, springtooth harrow, or other suitable field equipment.

D. Tilling: After the areas to be topsoiled have been brought to grade, and immediately prior to dumping and spreading the topsoil, the subgrade shall be loosened by disking or by scarifying to a depth of at least 2 inches to permit bonding of the topsoil to the subsoil.

SECTION II - TOPSOIL MATERIAL AND APPLICATION

Note: Topsoil on the existing site may often be used but it should meet the same standards as set forth in these specifications.

A. Materials - Topsoil shall be a sandy loam, clay loam, loam, silt loam, sandy clay loam, or other soil approved by the contracting representative. It shall not be a mixture of subsoil and contain no slag, cinders, stones, lumps of soil, sticks, roots, trash or other extraneous material larger than 1 1/2 inches in diameter. Topsoil must also be free of plants or plant parts of quackgrass, Johnsongrass, nutsedge, poison ivy, Canada thistle, or others as specified. All topsoil shall be tested by a recognized laboratory for pH and soluble salts. A pH of 4.5 to 7.5 is required. Soluble salts shall not be higher than 500 parts per million.

No sod shall be placed on soil which has been treated with soil sterilants until sufficient time has elapsed to permit dissipation of toxic materials.

B. Grading: The topsoil shall be uniformly distributed on the designated areas and it shall be a minimum depth of 3 inches after firming. Spreading shall be performed in such a manner that sodding can proceed with a minimum of additional soil preparation and tillage. Any irregularities in the surface resulting from topsoiling or other operations shall be corrected in order to prevent the formation of depressions or water pockets. Topsoil shall not be placed while in a frozen or muddy condition, or when the subgrade is excessively wet, or in a condition that may otherwise be deterimental to proper grading or proposed sodding.

C. Clean Up: After the topsoil has been spread and the final grades approved, it shall be cleaned of all grade stakes, surface trash, and other objects that would hinder maintenance of sodded and seeded areas. Paved areas over which hauling operations are conducted shall be kept clean, and any soil which may be brought upon the surfacing shall be promptly removed. The wheels of all vehicles shall be kept clean to avoid tracking soil on the surfacing of roads, walks, or other paved areas.

USDA, Soil Conservation Service
Columbus, Ohio

April 1972

STANDARDS AND SPECIFICATIONS FOR DIVERSION (Temporary and Permanent)

Definition

An earth channel with supporting ridge on the lower side constructed across the slope.

Scope

This standard covers the installation of diversions on construction sites and urban developments.

It includes temporary diversions, interceptors and diversion dikes as well as permanent diversions and level spreaders. Temporary diversions usually have a life expectancy of one year or less and the failure hazard is low.

Purpose

The purpose of this practice is to divert water from areas where it is in excess to sites where it can be used or disposed of safely.

Conditions Where Practice Applies

This practice applies to sites where runoff from higher lying areas is damaging (1) low lying areas, (2) cut or fill slopes or steeply sloping land, (3) critical sediment source areas in construction sites, (4) buildings and residences, and (5) active gullies or other erodible areas.

Diversions must have stable outlets. The site, slopes and soils must be such that the diversion can be maintained throughout its planned life.

Diversions are not applicable below high sediment producing areas unless land treatment practices or structural measures, designed to prevent damaging accumulations of sediment in the channels, are installed with or before the diversions.

Design Criteria

Location

Diversion locations shall be determined by considering outlet conditions, topography, land use, development layout, soil type and length of slope.

Avoid locations in or immediately below unstable or highly erosive soils unless special treatment or stabilization measures are previously applied.

Capacity

Runoff will be computed by the method outlined in Chapter 2, SCS Engineering Field Manual for Conservation Practices or by other acceptable methods. Runoff computations will be based upon the most severe soil and cover conditions that will exist in the area above the diversion during the planned life of the structure.

The minimum design 24-hour storm frequencies and freeboard will comply with Table 1. In all cases, the design storm frequency should be chosen to provide protection which is compatible with hazard or damage that would occur if the diversion should overtop.

Table 1 - Design Frequencies and Freeboard

DIVERSION TYPE	TYPICAL AREA OF PROTECTION	DESIGN FREQUENCY	FREEBOARD REQUIRED
Temporary	Construction Areas (roads, pipelines, etc.)	2 years	0.0
	Building Sites	5 years	0.0
Permanent	Land Areas, Play Fields, Recreation Areas, etc.	25 years	0.3 ft.
	Homes, Schools, Industrial Buildings, etc.	50 years	0.5 ft.

Design Velocity

Diversions should be designed so that the design velocities are as high as will be safe for the planned type of protective vegetation and the expected maintenance. Maximum permissible velocities are dependent upon (1) the erosion resistance of the soil in which the diversion is constructed and (2) the quality of the vegetation established and maintained in the diversion channel.

The maximum allowable velocities for diversions are listed in Table 2.

Table 2 - Permissible Velocities

Soil Texture	Allowable Velocity (V) in Ft./Sec.			
	Bare Channel	Condition of Vegetation		
		Poor	Fair	Good
Sand, silt, sandy loam, silt loam	1.5	1.5	2.0	3.0
Silty clay loam, sandy clay loam	2.0	3.0	4.0	5.0
Clay	2.5	3.0	5.0	6.0

Cross Section

The channel may be parabolic, V-shaped, or trapezoidal. The diversion shall be designed to have stable side slopes. The ridge height shall include a minimum settlement factor of 10 percent. The ridge shall have a minimum top width of 4 feet at the design water elevation. The minimum cross section shall meet the specified dimensions. The top of the constructed ridge shall not be lower at any point than the design water elevation plus the specified overfill for settlement.

Grade

Channel grade for diversions may be uniform or variable. The permissible velocity for the soil type and vegetative cover will determine the maximum grade. Level diversions with blocked ends may be used when adequate pipe outlets are provided.

Channel Dimensions

Channel dimensions will be determined using the appropriate retardance factor, or by Manning's formula using a suitable "n" value. Retardance factors will be determined using Table 3.

Table 3 - Vegetal Retardance Factors

Stand	Average length of vegetation	Degree of retardance	Stand	Average length of vegetation	Degree of retardance
Good	Longer than 24"	A	Fair	Longer than 24"	B
	11 to 24"	B		11 to 24"	C
	6 to 10"	C		6 to 10"	D
	2 to 6"	D		2 to 6"	D
	Less than 2"	E		Less than 2"	E

Parabolic channel sizes may be selected using charts in APPENDIX B-1, and trapezoidal channel sizes may be selected using APPENDIX B-2.

Outlets

Diversions are to have adequate outlets which will convey run-off without causing erosion. The following types of outlets are acceptable.

1. Natural or constructed vegetated outlets capable of safely carrying the design discharge. The outlet should be established and well vegetated prior to construction of the diversion.

2. Properly designed and constructed grade stabilization structures or storm sewers.

Level Spreader

A level lip spreader shall be used at diversion outlets discharging onto areas already stabilized by vegetation. Spreaders shall be excavated at least 6 inches deep into undisturbed soil. The bottom of the excavation and the downstream lip or edge shall be level. Minimum spreader lengths shall be based on the peak rate of flow from a 10-year frequency storm as indicated on the attached design standard for level spreaders.

Diversion Dikes and Interceptors

Diversion dikes for the temporary protection of cut or fill slopes or graded rights-of-way shall be installed in accordance with the attached design standards. Diverted runoff must be discharged onto a stabilized area or through a temporary slope protection structure. (See attached design standard.)

Protection Against Sediment

1. Temporary diversions - none required.

2. Permanent diversions - as a minimum, a filter strip of close growing grass shall be maintained above the channel. The width of the filter, measured from the center of the channel, shall be one-half the channel width plus 15 feet.

The diversion ridge and channel are to be seeded to grass to prevent erosion.

Small eroded areas and sediment producing channels draining into the diversion are to be shaped and seeded prior to or during the construction of the diversion.

CONSTRUCTION SPECIFICATION

DIVERSION

All dead furrows, ditches or other depressions to be crossed shall be filled before construction begins or as part of construction, and the earthfill used to fill the depressions will be compacted using the treads of the construction equipment. All old terraces, fence rows, or other obstructions that will interfere with the successful operation of the diversion will be removed.

The base for the diversion ridge is to be prepared so that a good bond is obtained between the original ground and the placed fill. Vegetation is to be removed and the base thoroughly disked prior to placement of fill.

The earth materials used in constructing the earthfill portions of the diversions shall be obtained from the diversion channel or other approved sources.

The earthfill materials used to construct diversions shall be compacted by routing the construction equipment over the fill in such a manner that the entire surface of the fill will be traversed by not less than one tread track of the equipment.

When an excess of earth material results from cutting the channel cross-section and grade, it shall be deposited adjacent to the supporting ridge unless otherwise directed.

The completed diversion shall conform to the cross-section and grade shown on the design.

Fertilizing, seeding, and mulching shall conform to the recommendations in the applicable vegetative standard and specification.

If there is no sediment protection provided on temporary diversions, it should be anticipated that periodic cleanout may be required.

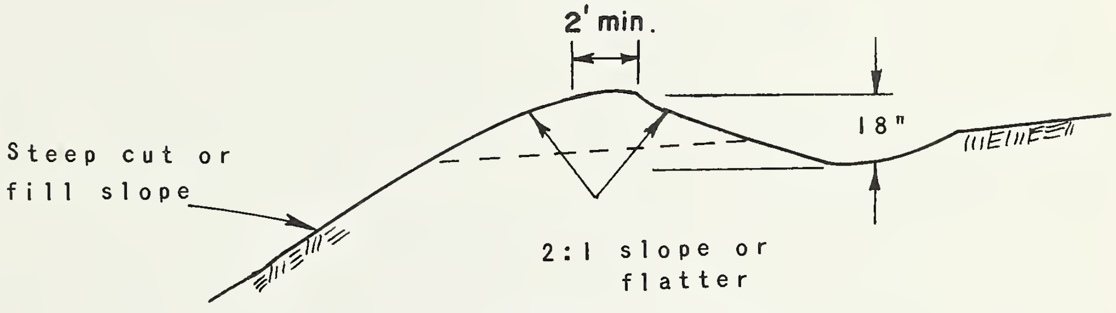
Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized. State and local laws concerning pollution abatement shall be complied with.

USDA, Soil Conservation Service
Columbus, Ohio

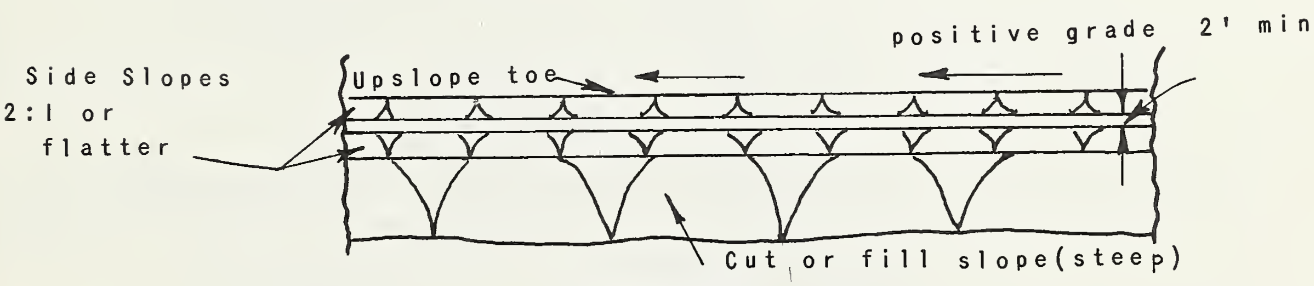
April 1972

DIVERSION DIKE ABOVE STEEP SLOPES

FOR USE ON DRAINAGE AREAS OF 5 ACRES OR LESS. LARGER AREAS REQUIRE A DIVERSION DESIGN.



CROSS SECTION



PLAN VIEW

DESIGN CRITERIA

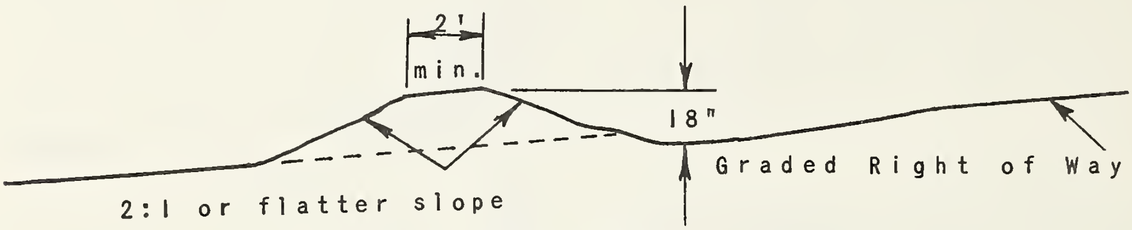
Top width - 2 ft. min.
Height (compacted fill) - 18 in. unless otherwise noted on the plans. (height measured from the upslope toe to top of the dike)
Side slopes - 2:1 or flatter.
Grade - dependent upon topography, but must have positive drainage to the outlet; may require vegetative or mechanical stabilization where grades are excessive.

GENERAL NOTES:

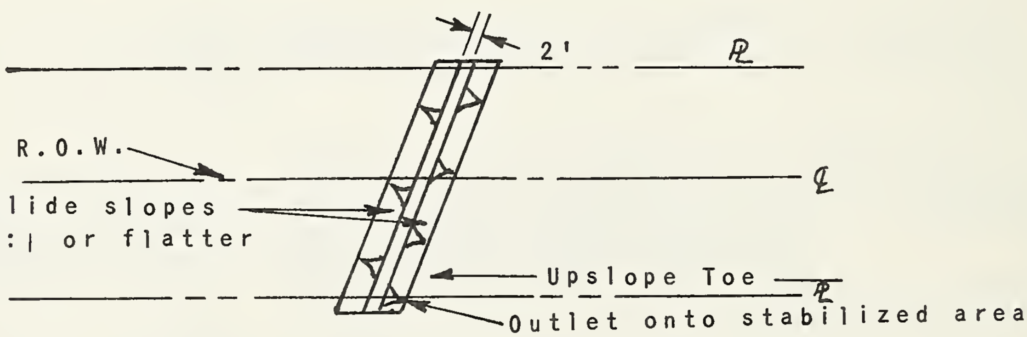
1. All diversions must have positive grade draining to a stabilized outlet.
2. Diverted runoff will outlet onto a stabilized undisturbed area, a prepared level spreader, or into a slope protection structure.
3. Periodic inspection and required maintenance must be provided.

TEMPORARY INTERCEPTOR DIVERSION FOR GRADED RIGHT-OF-WAY

FOR USE ON DRAINAGE AREAS OF 5 ACRES OR LESS. LARGER AREAS REQUIRE A DIVERSION DESIGN.



CROSS SECTION



PLAN VIEW

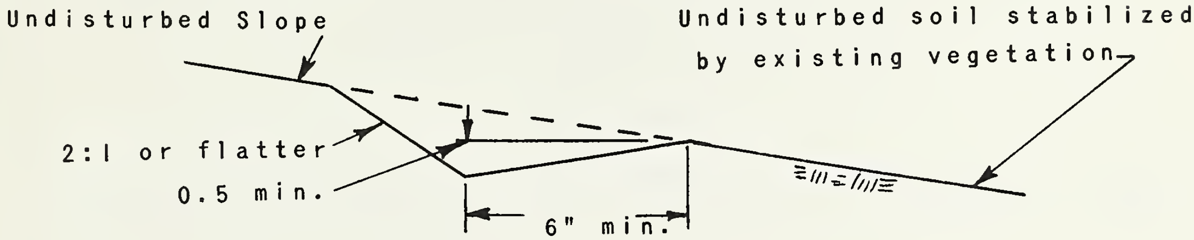
DESIGN CRITERIA

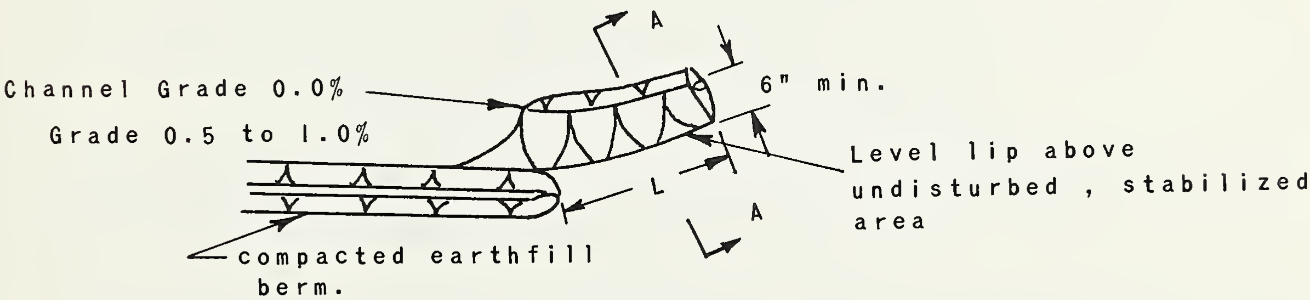
Top width - 2 ft. min.
Height - 18 in. unless otherwise noted on the plans (measured from the slope toe of the ridge).
Side slopes - 2:1 or flatter (flat enough to allow construction traffic to cross if desired).
Grade - 0.5% to 1.0%
Spacing - 200 to 300 ft. between diversions. (The steeper the slope the closer the spacing should be.)

GENERAL NOTES:

1. Top width may be wider and side slopes may be flatter, if desired.
2. Field location should be adjusted as needed to provide a stabilized safe outlet.
3. Diverted runoff shall outlet onto an undisturbed stabilized area, a prepared level spreader, or into a slope protection structure.
4. Periodic inspection and required maintenance must be provided.

LEVEL SPREADER





PLAN VIEW

DESIGN CRITERIA

Spreader length will be determined by estimating Q10 (10 year storm frequency) flow and selecting the appropriate length from Table.

Designed Q_{10} (cfs)	Minimum Length ("L" in Feet)
up to 10	15
11 to 20	20
21 to 30	26
31 to 40	36
41 to 50	44

GENERAL NOTES:

1. Construct level lip on zero percent grade to insure uniform spreading of storm runoff (converting channel flow to sheet flow).
2. Level spreaders must be constructed on undisturbed soil (not on fill).
3. Entrance to spreader must be graded in a manner to insure that runoff enters directly onto the zero percent graded channel.
4. Storm runoff converted to sheet flow must outlet onto areas already stabilized by existing vegetation.
5. Periodic inspection and maintenance must be provided to insure intended purpose is accomplished.

STANDARDS AND SPECIFICATIONS FOR GRASSED WATERWAY OR OUTLET

Definition

A natural or constructed waterway or outlet shaped or graded and established in suitable vegetation as needed for safe disposal of runoff water.

Purpose

To provide for the disposal of excess surface water from construction sites and urban areas without causing erosion.

Condition Where Practice Applies

This practice applies to sites where added capacity or vegetative protection or both are required to control erosion resulting from concentrated runoff.

Supplemental measures may be required with this practice. These may include such things as (1) grade control structures, (2) subsurface drainage to permit growing suitable vegetation and to eliminate wet spots that may be a nuisance, (3) a paved channel bottom or buried storm drain to handle frequently occurring storm runoff, base flow, or snowmelt.

Design Criteria

Capacity

The minimum capacity shall be that required to convey the peak runoff expected from a 24-hour, 10-year frequency storm. Runoff will be computed by the method outlined in Chapter 2, SCS Engineering Field Manual for Conservation Practices, or by other acceptable methods. Runoff computation will be based upon the most severe soil and cover conditions that will exist in the area draining into the waterway during the planned life of the structure.

Velocity

The design velocity is to be based upon soil, duration of flow, and type and quality of vegetation. Design velocities will be determined using charts in APPENDIX B-3, except that velocities exceeding 5 feet per second shall be used only where good cover and proper maintenance can be attained.

Channel Dimensions

Channel dimensions will be determined using the appropriate retardance factor, or by Manning's formula using a suitable "n" value. Parabolic channel sizes may be selected using charts in APPENDIX B-3. On steep areas where stone centered waterways are required, the channel sizes may be selected using APPENDIX B-4.

Cross Section

The cross section may be parabolic, vee-shaped, or trapezoidal.

Width

The bottom width of trapezoidal waterways or outlets are not to exceed 50 feet unless multiple or divided waterways are used, or other means provided to control meander of low flow.

Depth

The minimum depth of waterway receiving water from diversions or tributary channels is to be that required to keep the design water surface in the waterway or outlet at or below the design water surface elevation in the diversion or other tributary channel at their junction. To provide for loss in channel capacity due to vegetal matter accumulation, sedimentation, and normal seedbed preparation, the channel depth and width should be increased proportionally to maintain the hydraulic properties of the waterway. In parabolic channels this may be accomplished by adding 0.3 foot to the depth and 2 feet to the top width of the channel. This is not required on waterways located in natural watercourses.

Where a paved bottom is used in combination with vegetated side slopes, the paved section is to be designed to handle the base flow, snowmelt or runoff from a one-year frequency storm whichever is greater. The flow depth of the paved section shall be a minimum of 0.5 foot.

Drainage

In areas with high water table or seepage problems, subsurface drainage or stone centers will be provided. A minimum drainage coefficient of 3/8 inch in twenty-four (24) hours is to be used for subsurface drainage design. An open joint storm drain may be used to serve the same purpose and also handle storm runoff, base flow or snowmelt. The storm drain should be designed

designed to handle base flow, snowmelt, or the runoff from at least a one-year frequency storm, whichever is greater.

CONSTRUCTION SPECIFICATION

GRASSED WATERWAY OR OUTLET

All trees, brush, stumps and other objectionable material shall be removed and disposed of in a manner so that they will not interfere with construction or the proper functioning of the waterway or outlet.

The waterway or outlet shall be constructed to the dimensions specified on the design, and the cross section shall be free from bank projections or other irregularities.

All ditches or other depressions below the designed grade will be backfilled with fill material that is free from brush, roots, sod or other perishable material, and rocks in excess of 6 inches in diameter. Backfill will be placed in approximately uniform horizontal layers of not more than 9 inches in thickness and each layer will be compacted using the treads or tracks of the construction equipment.

All excavated material not needed in the construction of the waterway or outlet shall be spread or disposed of so it will not interfere with the flow of water into the waterway.

When specified on the design, topsoil from the construction area will be preserved by stockpiling. After the waterway has been constructed to proper grades and cross section with proper allowance for topsoil, the topsoil will be uniformly spread over the area to a minimum depth of four (4) inches.

Waterways or outlets shall be protected against erosion by vegetative means as soon after construction as practical and before diversions or other channels are outletted into them. Consideration should be given to sodding channels to provide erosion protection immediately after construction.

Seeding, fertilizing, mulching, and sodding shall be performed in accordance with applicable standards.

USDA, Soil Conservation Service
Columbus, Ohio

April 1972

STANDARDS AND SPECIFICATIONS FOR LAND GRADING

Definition

Reshaping the ground surface by grading to planned grades which are determined by engineering survey and layout.

Purpose

The practice is for one or more of the following: Provide more suitable sites for buildings, facilities and other land uses; improve surface drainage; and control erosion.

Conditions Where Practice Applies

The practice is applicable where grading to planned elevations is practical.

Planning Criteria

The grading plan and installation shall be based upon adequate surveys and investigations. The plan is to show the location, slope, cut, fill, and finish elevation of the surfaces to be graded and the auxiliary practices for safe disposal of runoff water, slope stabilization, erosion control and drainage such as waterways, lined ditches, diversions, grade stabilization structures, retaining walls, and surface and subsurface drains.

The development and establishment of the plan shall include the following:

1. The cut face of the earth excavation which is to be vegetated shall not be steeper than 2 horizontal to 1 vertical. Cut slopes of areas not to be vegetated shall be at the safe angle of respose for the materials encountered.

2. The permanent exposed faces of fills shall be no steeper than 2 horizontal to 1 vertical.

3. Provisions are to be made to safely conduct surface water to storm drains or suitable natural water courses and to prevent surface runoff from damaging cut faces and fill slopes.

4. Subsurface drainage is to be provided (1) in areas having high water table, or (2) to intercept seepage that would affect slope stability, building foundations or create undesirable wetness.

5. Excavations shall not be made so close to property lines as to endanger adjoining property without supporting and protecting such property from erosion, sliding, settling or cracking.

6. No fill is to be placed where it will slide, or wash upon the premises of another, or so placed adjacent to the bank of a channel as to create bank failure or reduce the natural capacity of the stream.

7. Fills are to consist of material from cut areas, borrow pits, or other approved sources.

CONSTRUCTION SPECIFICATION

LAND GRADING

Timber, logs, brush, rubbish, and vegetable matter which will interfere with the grading operation or affect the planned stability of fill areas shall be removed and disposed of according to the plan.

Topsoil is to be stripped and stockpiled in amounts necessary to completely finish grading of all exposed areas requiring topsoil for the establishment of vegetation.

Fill material is to be free of brush, rubbish, rocks, logs, and stumps in amounts that will be detrimental to constructing stable fills.

Cut slopes which are to be topsoiled will be scarified to a minimum depth of 3 inches prior to placement of topsoil.

Unless otherwise regulated by stricter controls of local building codes, all fills intended to support buildings, structures, sewers and conduits are to be compacted to a minimum of 90 percent of standard proctor with proper moisture control. Compaction of other fills will be as required to reduce slipping, erosion or excess saturation.

Frozen materials or soft, mucky or easily compressible materials are not to be incorporated in fills intended to support buildings, parking lots, roads, structures, sewers or conduits.

Maximum thickness of layers of fills to be compacted are not to exceed 8 inches.

All areas are to be rough graded to within 0.2 foot of the planned elevation after allowance has been made for thickness of topsoil, paving or other installations.

All disturbed areas shall be left with a neat and finished appearance.

Seeding, fertilizing, mulching, and sodding shall be in accordance with applicable standards.

STANDARDS AND SPECIFICATIONS FOR SEDIMENT AND DEBRIS BASIN (Temporary and Permanent)

Definition

A barrier or dam constructed across a waterway or at other suitable locations to form a basin for retaining sediment and other waterborne debris.

Scope

This standard applies to sediment and debris basins formed by an embankment, an excavation, or a combination of an embankment and excavation. This standard is limited to the installation of sediment and debris basins on sites where:

1. Failure of the structure will not result in loss of life, damage to homes, or interruption of use or service of public utilities (SCS Hazard Class A).

2. Drainage area does not exceed 200 acres.

3. The water surface area at the crest of the emergency spillway does not exceed 5 acres.

Purpose

To provide a permanent or temporary means of trapping and storing sediment from eroding areas in order to protect properties below the basin from damage by excessive sedimentation and debris.

Conditions Where Practice Applies

Where physical conditions of land ownership do not allow the treatment of the sediment source by the installation of erosion control measures to reduce runoff and erosion. It also may be used as a permanent measure, or temporary measure during grading and development of areas upstream from the basin. All temporary structures should be removed once the development is complete and the area is permanently protected against erosion by vegetative or mechanical means.

CLASSES OF SEDIMENT AND DEBRIS BASINS

TABLE 1

Class	Max. Drainage Area (Acres)	Max. Height[1/] of Embankment (ft.)	Emergency Spillway Required	Design Storm Frequency
1[2/]	20	5	No	10 yrs.
2	20	10	Yes	10 yrs.
3	200	20	Yes	25 yrs.

1/ Height is measured from the low point of original ground along the centerline of dam to the top of dam for Class 1 and to the crest of emergency spillway for Classes 2 and 3.

2/ Class 1 basins are to be used only where site conditions are such that it is impractical to construct an emergency spillway in undisturbed ground, and they will only be used as temporary structures.

Sediment Capacity

The capacity of the sediment basin to the elevation of the crest of the pipe spillway is equal to the volume of expected sediment yield from unprotected portions of the drainage area during the planned useful life of the structure. The annual volume of expected sediment may be determined using the following table:

TABLE 2

Disturbed Area (Acres)	Annual Sediment Volume (Ac. Ft.)	Disturbed Area (Acres)	Annual Sediment Volume (Ac. Ft.)
1	1.0	40	2.5
2	1.1	60	2.8
4	1.3	80	3.1
6	1.5	100	3.3
8	1.6	125	3.5
10	1.7	150	3.7
20	2.1	175	3.9
30	2.3	200	4.0

Where unanticipated storm events or other conditions produce a sediment yield which reduces the basin's capacity to 60% of the designed capacity, the basin must be cleaned out to its original capacity.

Spillway Design

Runoff Computations

Runoff will be computed by the method outlined in Chapter 2, SCS Engineering Field Manual for Conservation Practices or other acceptable methods. Runoff computations will be based upon the soil and cover conditions expected to prevail during the construction period of the development.

The combined capacities of the pipe and emergency spillways will be sufficient to pass the peak rate of runoff for the design storm shown in Table 1.

Pipe Spillways

The pipe spillway will consist of a vertical pipe or box-type riser joined to a conduit which will extend through the embankment and outlet beyond the downstream toe of the embankment. The minimum diameter of the conduit will be 8 inches. The riser will be perforated to provide for a gradual drawdown after each storm event. The minimum average capacity of the pipe spillway will be sufficient to discharge 5 inches of runoff from the drainage area in 24 hours (0.21 cfs per acre of drainage area). Sizes for pipe conduits may be determined using charts in APPENDIX B-5. The riser of the pipe spillway shall have a cross-sectional area at least 1.3 times that of the barrel.

a. Crest Elevation - When used in combination with emergency spillways, the crest elevation of the riser shall be at least 1 foot or the head required to prime the pipe conduit, whichever is greater, below the elevation of the control section of the emergency spillway. If no emergency spillway is provided, the crest elevation will be at least 3 feet below the settled elevation of the top of the embankment.

b. Perforated Riser - Metal pipe risers shall be perforated with1-1/2 inch diameter holes spaced 8 inches vertically and 10-12 inches horizontally around the pipe. The perforated portion of the riser shall extend down to the planned drawdown elevation and at least one-half the height of the riser. Box type risers shall be ported or have some means for complete drainage down to the planned drawdown elevation within 5 days.

c. Anti-Vortex Device - An anti-vortex device shall be installed at and firmly attached to the top of the riser. The anti-vortex device should be a vertical steel plate and installed parallel with the pipe barrel. The minimum horizontal dimension is the diameter of the riser plus 12 inches, and the minimum vertical dimension is equal to the diameter of the pipe barrel.

d. Base - The riser shall have a base attached with a watertight connection. The base shall have sufficient weight to prevent flotation of the riser.

e. Trash Rack - An approved trash rack shall be firmly attached to the top of the riser if the pipe spillway conveys 25 percent or more of the peak rate of runoff from the design storm.

f. Anti-Seep Collars - Anti-seep collars will be installed around the pipe barrel for all installations where the height of earth fill over the top of the pipe exceeds 5 feet.

The anti-seep collars and their connections to the pipe barrel shall be watertight. The maximum spacing between collars shall be 14 times the minimum projection of the collar measured perpendicular to the pipe. The first collar should be located 10 to 12 feet downstream from the riser.

g. Outlet Protection - The pipe barrel shall outlet approximately at natural ground elevation beyond the downstream toe of the embankment, and protection against scour shall be provided. Protective measures may include rock riprap, paving, plunge pool or use of other approved methods. Where a plunge pool is used, the pipe barrel must extend 8 feet downstream from the toe of the embankment.

Emergency Spillways

Emergency spillways shall be constructed for all Class 2 and 3 sediment basins. The emergency spillway cross-section will be trapezoidal with a minimum bottom width of 8 feet. Steepest side slopes shall be 3:1.

For Class 1 sediment basins, the embankment will be used as an emergency spillway. The downstream slope of the embankment shall be 5:1 or flatter and the embankment must be immediately protected against erosion by sodding, rock riprap, asphalt coating or other approved methods.

a. Capacity - The minimum capacity of the emergency spillway shall be that required to pass the peak rate of runoff from the design storm, minus the capacity of the pipe spillway. Emergency spillway dimensions can be determined by using APPENDIX B-5.

b. Velocities - The maximum allowable velocity of flow in the exit channel shall be 6 feet per second for vegetated channels. For spillways with erosion protection other than vegetation, velocities shall be in the safe range for the type of protection used.

c. Freeboard - Freeboard is the difference between the design flow elevation (Hp) of the emergency spillway and the top of the settled embankment. The minimum freeboard for all Class 2 and Class 3 basins with less than 100 acre drainage areas shall be 1 foot. On drainage areas in excess of 100 acres, the minimum freeboard shall be 1 foot above the water surface in the reservoir with the emergency spillway flowing at design depth, or 3 feet above the emergency spillway crest elevation, whichever is greater. In addition, a minimum 15% allowance for settlement will be added to the settled embankment elevation.

Embankment (Earth Fill)

For Class 1 basins, the minimum top width shall be 10 feet, the upstream slope shall be no steeper than 3:1, and the downstream slope shall be no steeper than 5:1.

For Class 2 and 3 basins, the minimum top width shall be 10 feet, and the side slopes shall be no steeper than 2-1/2:1.

Embankments may also be constructed of:

a. Creosoted pressure treated timber crib - rock filled.

b. Precast reinforced concrete crib - rock filled.

c. Gabions - rock filled.

Note: When the above materials are used for the embankment, a pipe spillway is not required, however, the dam shall be pervious enough to allow for drainage during times of low inflow. Basins of this type can only be used when sediment to be trapped is coarse grained material such as GW or GP (Unified Classification System).

Erosion and Pollution Control

Construction procedures will be done in such a manner to minimize soil erosion and water pollution.

Vegetative Cover

Provide for the protection of the embankment, emergency spillway, and other disturbed areas by vegetation or other suitable means. Fertilizing, seeding, and mulching shall conform to the recommendations in the applicable vegetative standard and specification.

Safety

Fencing necessary to restrict accessibility for reasons of safety will be installed. Warning signs of danger shall be installed as necessary.

CONSTRUCTION SPECIFICATION

SEDIMENT BASIN

Embankment Basins

The foundation area shall be cleared of all trees, stumps, roots, brush, boulders, sod, and debris. All channel banks and sharp breaks shall be sloped to no steeper than 1:1. All topsoil containing excessive amounts of organic matter shall be removed. The surface of the foundation area will be thoroughly scarified before placement of the embankment material.

The cutoff trench shall be excavated to the lines and grades shown on the plans and shall be backfilled with suitable material in the same manner as specified for earth embankment. The trench shall be kept free of standing water during backfill operations.

Existing stream channels crossing the foundation area shall be sloped no steeper than 1:1 and deepened and widened as necessary to remove all stones, gravel, sand, roots, and other objectionable material and to accommodate compacting equipment. Such channels shall then be backfilled with suitable material as specified for earth embankment.

The pipe conduit barrel shall be placed on a firm foundation to the lines and grades shown on the plans. Selected backfill material shall be placed around the conduit in layers and each layer shall be compacted to at least the same density as the adjacent embankment.

The completed spillway excavation shall conform to the lines, grades, bottom width, and side slopes shown on the plans as nearly as skillful operation of the excavating equipment will permit.

All borrow areas outside the pool area shall be graded and left to such a manner that they are well drained.

The material placed in the fill shall be free of all sod, roots, frozen soil, stones over 6 inches in diameter, and other objectionable material. The placing and spreading of the fill material shall be started at the lowest point of the foundation and the fill shall be brought up in approximately 6 inch horizontal layers or of such thickness that the required compaction can be obtained with the equipment used. The construction equipment shall be operated over the area of each layer in a way that will result in the required compaction. Special equipment shall be used when the required compaction cannot be obtained without it. The constructed elevation shall be a minimum of 15% above design elevation to compensate for settling.

The distribution and gradation of materials throughout the fill shall be such that there will be no lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. Where it is necessary to use materials of varying texture and gradation, the more impervious material shall be placed in the upstream and center portions of the fill.

The moisture content of fill material shall be such that the required degree of compaction can be obtained with the equipment used.

Fill shall not be placed on frozen, slick or saturated soil.

The topsoil material saved in the site preparation shall be placed as a top dressing on the surface of the emergency spillways, embankments, and borrow areas. It shall be evenly spread to a thickness as directed by the technician.

A protective cover of vegetation shall be established on all exposed surfaces of the embankment, spillway, and borrow areas to the extent practicable under prevailing soil and climatic conditions.

The embankment and spillway shall be fenced where necessary to protect vegetation.

Seedbed preparation, seeding, fertilizing, and mulching shall comply with technical guides.

The construction of impoundment must comply with Ohio State laws.

Excavated Basins

The completed excavation shall conform to the lines, grades and elevation shown on the plans as nearly as can be achieved by skillful operation of the excavating equipment.

The material excavated from the basin shall be placed in one of the following ways so that its weight will not endanger the stability of the side slopes and where it will not be washed back into the basin by rainfall:

1. Uniformly spread to a height not exceeding 3 feet with the top graded to a continuous slope away from the basin.

2. Uniformly placed or shaped reasonably well with side slopes assuming the natural angle of repose for the excavated material behind a berm width equal to the depth of the basin, but not less than 12 feet.

3. When excavated materials are used to construct a low embankment, the embankment shall have a minimum top width of 10 feet, and the steepest side slopes shall be 3 to 1 upstream and 5 to 1 downstream. All sod and other unstable or deleterious material will be removed from under the embankment, prior to placement of excavated material.

Final Disposal

In the case of temporary structures when the intended purpose has been accomplished and the drainage area properly stabilized, the embankment and resulting silt deposits are to be leveled or otherwise disposed of in accordance with the plan.

USDA, Soil Conservation Service
Columbus, Ohio

April 1972 -

STANDARDS AND SPECIFICATIONS FOR DRAINAGE-INTERCEPTOR

Definition

A conduit, such as tile, pipe, or tubing or channel installed across the slope which collects and conveys seepage water.

Purpose

Interceptor ditches or drains located across the flow of ground water or seepage are installed primarily for intercepting subsurface flow moving down a slope. While this type of drainage intercepts and diverts both surface and subsurface flows, the removal of surface water is generally referred to as diversion drainage and the removal of subsurface water is referred to as interceptor drainage.

Conditions Where Practice Applies

Interceptor drains are used to intercept ground water or seepage from adjoining highlands. Most ground water for which drainage is required derives from recent rainfall that accumulates on or within the upper ground surface and, after replenishing the soil to water holding capacity, moves downward through the soil to the water table or a barrier above the water table. Here it accumulates and moves laterally toward an outlet. This water accumulation in the subsurface often causes slips and slides in the area where it reaches the surfaces.

Ditches may be used where drains are not feasible. They are used in shallow hardpan soils where the depth of the soil does not permit installation of tile or tubing. Ditches must be deep enough to tap and provide an outlet for ground water found in shallow, permeable strata or water bearing sand.

An outlet for the drainage system shall be available. The outlet shall be adequate for the quantity of water to be disposed of without causing erosion damage.

Design Criteria

The design and installation shall be based on adequate surveys and investigations.

Required Capacity of Drains

The required capacity shall be determined from the following table when actual on-site values are not known.

INTERCEPTOR DRAIN INFLOW RATES

Soil Texture	Inflow Rate Per 1000 Feet of Line in CFS 1/			
	Land Slope %			
	0-2	2-5	5-12	over 12
Coarse sand and gravel	1.00	1.10	1.20	1.30
Sand	0.50	0.55	0.60	0.65
Sandy loam	0.25	0.28	0.30	0.33
Silt loam	0.10	0.11	0.12	0.13
Clay and clay loam	0.20	0.22	0.24	0.26

1/ Discharge of flowing springs or direct entry of surface flow through a surface inlet or filter must be added to the values in the chart. Such flow should be measured or estimated.

Size of Drain

The size of the drain may be determined by using the appropriate table in APPENDIX B-6 or the size may be computed by applying Manning's formula based on one of the following assumptions:

1. Hydraulic grade line parallel to the bottom grade of the drain with the drain flowing full at design flow.

2. The drain flowing part full where a steep grade or other condition requires excess capacity.

3. Drain flowing under pressure with hydraulic grade line set by site conditions on a grade which differs from that of the drain. This procedure shall be used only where surface water inlets or nearness of the drain to outlets with fixed water elevations permit satisfactory estimates of hydraulic pressure and flow under design conditions.

The minimum size shall be 4 inches.

Depth and Location

The depth and location of the drain shall be based on site conditions including soils, soil borings, topography, groundwater conditions, and outlets.

The minimum depth of cover shall be 24 inches.

Envelopes and Filters

All interceptor drains shall be provided with a 3-inch sand and gravel envelope to provide bedding for the drain and to improve the permeability in the zone around the drain. Envelope material shall consist of sand gravel material, all of which will pass a 1½ inch sieve, 90 to 100 percent shall pass the 3/4 inch sieve and not more than 10 percent shall pass the No. 60 sieve.

When site conditions require a filter to prevent sediment accumulation in the conduit it shall consist of fiberglass filter material that completely encases the drain. It shall be manufactured from borosilicate type glass and the manufacturers shall certify that it is suitable for underground use. The fibers shall be of variable size, with some larger fibers intertwined in the mat in a random manner.

CONSTRUCTION SPECIFICATION

DRAINAGE-INTERCEPTOR

Inspection and Handling of Materials

Materials for drains shall be inspected before installation. Clay and concrete shall be protected from freezing and thawing prior to installation. Bituminized fiber and plastic pipe and tubing shall be protected from hazards causing deformation or warping. All materials shall be satisfactory for intended use and shall meet applicable specifications and standards.

Placement

All drains, both flexible as plastic tubing and non-flexible as clay and concrete tile shall be laid to line and grade and completely surrounded with a minimum of 3 inches of envelope material. A filter where required shall cover all open joints and perforations.

The gap between the drain joints shall not exceed:

Muck	1/8" to 3/8"
Clay soils	1/8" to 1/4"
Loamy soils	1/8"
Sandy soils	1/16" (use filter)

The upper end of the drain shall be capped with concrete or other durable material.

Earth backfill material shall be placed in the trench in such a manner that displacement of the drain will not occur.

USDA, Soil Conservation Service
Columbus, Ohio

April 1972

STANDARDS AND SPECIFICATIONS FOR SLOPE PROTECTION STRUCTURE (Temporary Chute or Flume)

Definition

A temporary channel of bituminous concrete, Portland cement concrete, or comparable material to conduct surface runoff from the top of a slope to the bottom of the slope.

Purpose

The purpose of this practice is to convey storm runoff safely down cut and fill slopes to minimize erosion.

Conditions Where Practice Applies

Chutes or flumes are to be used where concentrated water will cause excessive erosion on cut and fill slopes. The structures can be left in place until adequate vegetation and the permanent drainage system has been installed.

Design Criteria

The temporary chutes or flumes are divided into two size groups as follows:

Size Group A

1. The height of the dike at the entrance (H) equals 1.5 feet.
2. The depth of flow down the chute (d) equals 8 inches.
3. The length of the inlet and outlet sections (L) equals 5 feet.

Size Group B

1. The height of the dike at the entrance (H) equals 2 feet.
2. The depth of flow down the chute (d) equals 10 inches.
3. The length of the inlet and outlet sections (L) equals 6 feet.

Each size group has various bottom widths and allowable drainage areas as shown in the following tabulation:

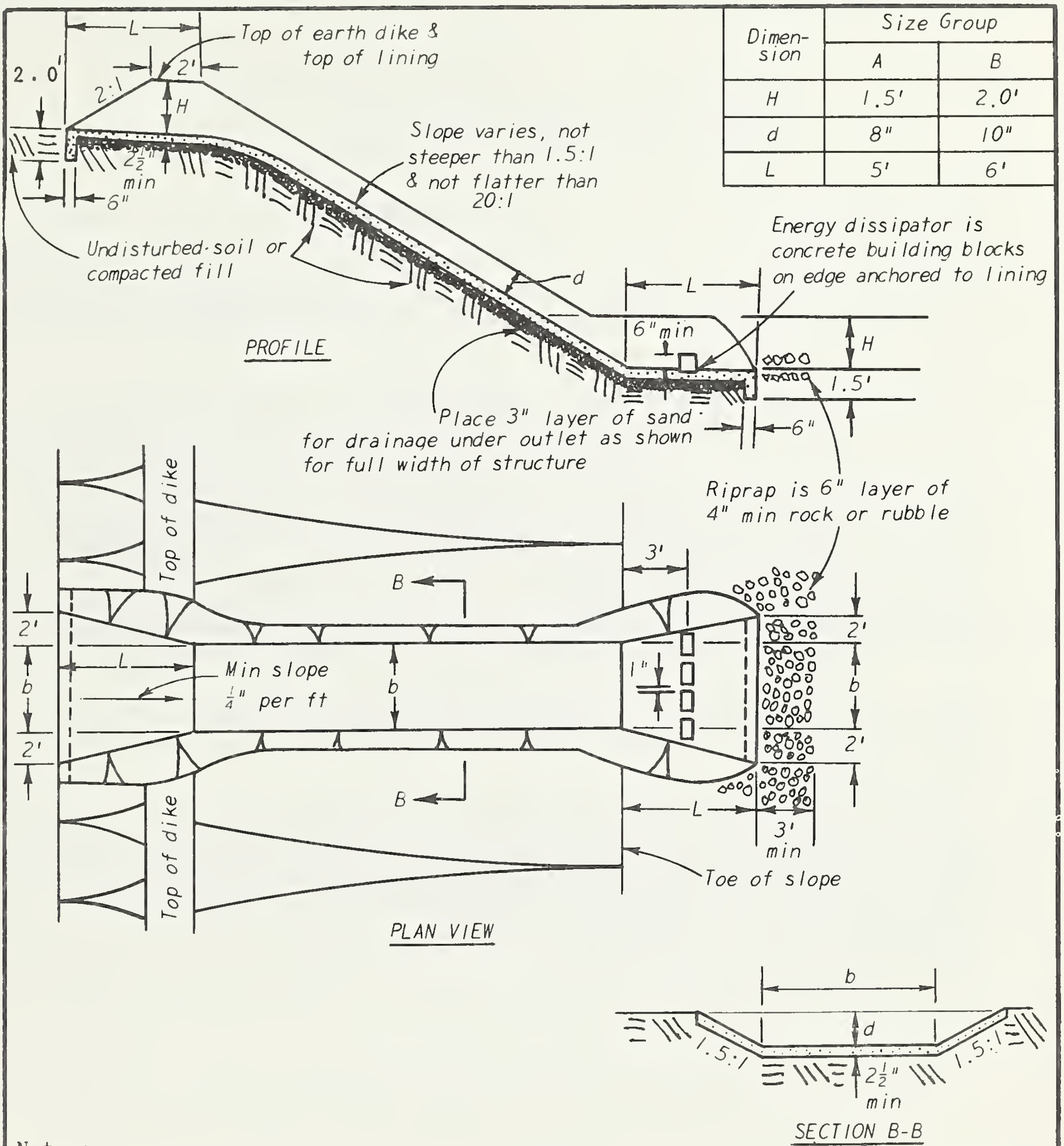
Size[1]	Bottom Width, b, ft.	Maximum Drainage Area acres	Size[1]	Bottom Width, b, ft.	Maximum Drainage Area acres
A-2	2	5	B-4	4	14
A-4	4	8	B-6	6	20
A-6	6	11	B-8	8	25
A-8	8	14	B-10	10	31
A-10	10	18	B-12	12	36

1/ The size is designated with a letter and a number, such as A-6 which means a chute or flume in Size Group A with a 6 foot bottom.

If a minimum of 75% of the drainage area will have a good grass or woodland cover throughout the life of the structure, the drainage areas listed above may be increased by 50%. If a minimun of 75% of the drainage area will have a good mulch cover throughout the life of the structure, the drainage area listed above may be increased by 25%.

For dimensions, grades, and construction details, see attached design standard. Detail designs are required for drainage areas larger than those indicated above.

Dimension	Size Group A	Size Group B
H	1.5'	2.0'
d	8"	10"
L	5'	6'



Notes:

1. Lining shall be Portland Cement concrete, bituminous concrete or comparable material.
2. Some type of energy dissipator, such as the one shown above, must be used to prevent erosion at the outlet.
3. The size is designated with a letter and a number, such as A-6, which means Size Group A with a 6 ft. bottom width (b). For structure dimensions, see table in upper right hand corner.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	GRADE STABILIZATION STRUCTURE (Temporary)	

CONSTRUCTION SPECIFICATION

SLOPE PROTECTION STRUCTURE
(Temporary Chute or Flume)

1. The structure shall be placed on undisturbed soil or well compacted fill.

2. The cut or fill slope shall not be steeper than 1 vertical to 1.5 horizontal (1.5:1) and should not be flatter than 20:1.

3. The top of the earth dikes shall not be lower at any point than the top of the lining at the entrance of the structure.

4. The lining should be placed beginning at the lower end and proceding up the slope to the upper end. The lining shall be well compacted and free of voids. The lining surface shall be reasonably smooth.

5. The entrance floor at the upper end of the structure shall have a slope toward the outlet of 1/4 to 1/2 inch per foot.

6. Concrete shall have a minimum cement content of 6 bags per cubic yard and a maximum water content of 6 gallons per bag of cement.

7. Adequate vegetative protection and drainage works shall be installed within the expected life of the structure which is considered to be about 18 months. The structure shall be removed after serving its useful life and the site is properly graded and seeded.

USDA, Soil Conservation Service
Columbus, Ohio

April 1972

STANDARDS AND SPECIFICATIONS FOR SLOPE PROTECTION STRUCTURE (Temporary Pipe Drop)

Definition

A temporary pipe installed down a bank slope to safely conduct runoff water from the top to the bottom of the bank slope. (See attached design standard.)

Purpose

The purpose of this practice is to convey storm runoff safely down cut or fill slopes to minimize erosion.

Condition Where Practice Applies

Pipe drops are to be used to stabilize cut or fill banks where water concentrations would cause erosion. Site conditions are such that vegetative measures can be installed and the temporary structure removed within 18 months after installation.

Design Criteria

Capacity

The design capacity for temporary pipes shall be as required to pass the peak runoff expected from a 24-hour, 2-year frequency storm. Runoff will be computed by the method outlined in Chapter 2, SCS Engineering Field Manual for Conservation Practices, or by other acceptable methods. Runoff computation will be based upon the most severe soil and cover conditions that will exist in the area draining into the pipe drop during the planned life of the structure.

Pipe capacities may be determined from the chapter in APPENDIX B-7.

Inlet

A hood inlet type entrance shall be used (APPENDIX B-7). The pipe drop inlet shall be protected by riprap or concrete.

Outlet

Outlet protection shall be provided by riprap or other means.

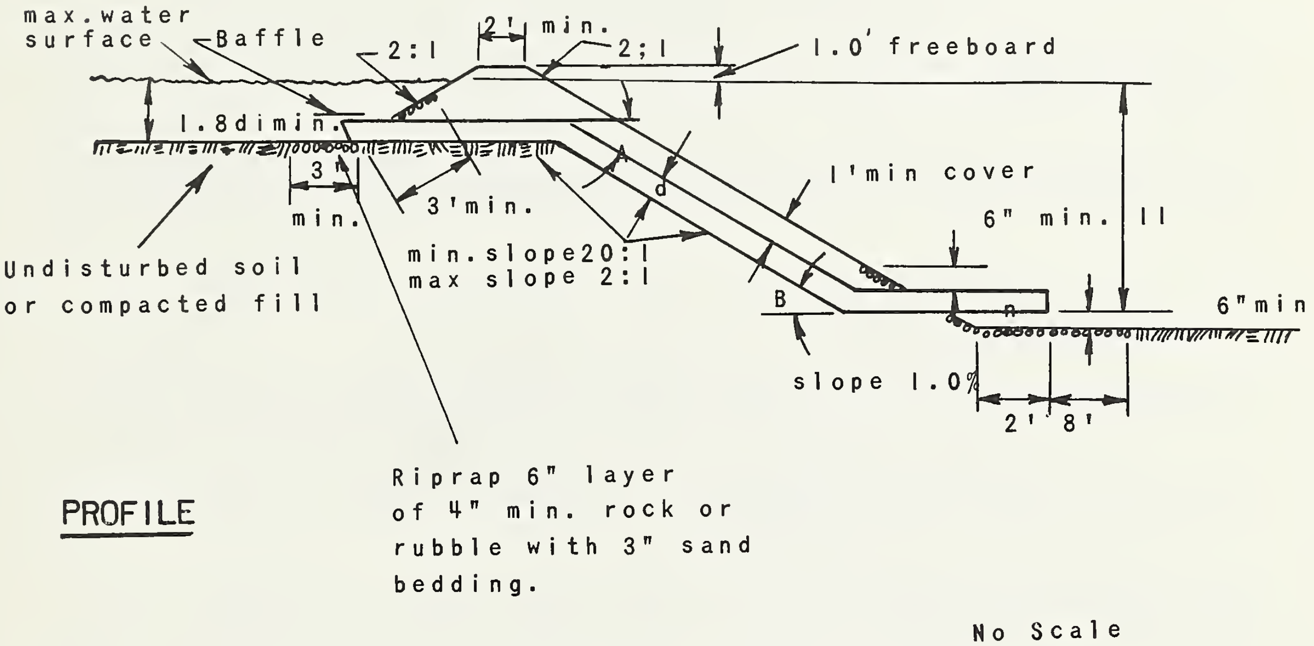
Pipe Size

The pipe diameter shall be determined from design charts in APPENDIX B-7. The pipe shall have sufficient flow area based on head discharge relationships to carry the design capacity.

Dike

Pipe drops should be used in conjunction with and as an outlet for diversion dikes. The dike height above the pipe inlet invert shall be adequate to contain a water elevation sufficient to cause full pipe flow plus an allowance of at least 1.0 feet for freeboard. A water depth of 1.8 times the pipe diameter above the pipe inlet invert is required to assure full pipe flow.

SLOPE PROTECTION STRUCTURE (TEMPORARY)



PROFILE

Notes:

1. If an emergency spillway is used, its crest shall be at least 1.8d above the intert of the hooded inlet and at least 0.5' free-board shall be provided above its maximum flow depth.

2. Bend A is optional to ease installation.

3. The baffle shall be similar to that illustrated in APPENDIX B-7.

4. See APPENDIX B-7 for capacity data on both CMP and smooth metal pipe.

5. A reinforced concrete slab may be substituted for the riprap at the pipe inlet. The slab shall be at least 6" thick with a minimum of one grid of #3 re-bars at 6" spacing. The slab shall be bedded with at least 3" of clean sand.

CONSTRUCTION SPECIFICATION

SLOPE PROTECTION STRUCTURE
(Temporary Pipe Drop)

1. The structure shall be placed in undisturbed soil or well compacted fill.

2. The cut or fill slope shall not be steeper than 1 vertical to 1.5 horizontal (1.5:1) and should not be flatter than 20:1.

3. The pipe shall be embedded in the embankment to a depth that will insure stability.

4. Protective measures of concrete or riprap shall be installed at the inlet and outlet as needed to protect against erosion.

5. The pipe shall be of smooth or corrugated metal of the required strength and durability.

6. Backfill shall be placed in layers and tamped to insure adequate compaction.

7. Adequate vegetative protection and drainage works shall be installed within the expected life of a temporary structure which is considered to be about 18 months. The structure shall be removed after serving its useful life and the site is properly graded and seeded.

METHOD FOR DETERMINING SEDIMENT LOSSES IN OHIO

The method of estimating rainfall-erosion sediment losses described herein applied to construction sites and similarly disturbed and unvegetated areas. Losses estimated are for sheet erosion normally occurring on relatively short slopes. It does not account for large quantities of soil material that may be lost by rill and gully erosion resulting from heavy concentrations of runoff water. This method is based on the USDA Universal Soil-Loss Equation.

$$A = R\ K\ L\ S$$

Where . . . . A is the computed soil loss per unit area

R is the rainfall factor

K is the soil erodibility factor

L is the slope-length factor

S is the slope-gradient factor

The K values in Table I provide a relative scale of the erodibility of the various soils and subsoils.

In Table I the topsoils and subsoils in Ohio have been grouped into two generalized categories. It should be possible to place the soil material at a given site into one of these categories by examination. A specific soil for a given area could be determined with the assistance of the local Soil Conservation Service office.

The topsoils are rated in the first generalized category and the subsoils in the second general category. Exposed subsoils are most likely to occur in cuts and scalped areas. Filled areas are likely to be subsoil material.

It should be recognized that in fills the soil material is sometimes not well compacted. If so, it would be more erodible than similar material that is well compacted. The K values in the tables are calculated using estimated bulk densities of undisturbed soils.

After the K value has been determined for a given site the R or Rainfall factor must be determined. This can be accomplished by checking Chart I. Chart I is a map of Ohio which has been divided into three rainfall factor areas: R - 125, R = 150, and R = 175. Locate the site on the map and the R factor for the site.

After the K value and R factor has been determined for a given site the potential sediment production from sheet erosion can be determined by referring to Table II. For the indicated length and percent of slope, the value is given in tons per acre per year. This value is the potential or predictable amount of sediment production from a given site under average climatic conditions.

Table III may be used to convert sediment production or soil loss from tons to cubic yards if this information is desired.

Table IV shows the yearly erosion hazard distribution by months.

Example:

A construction site in the Dayton Area with a slope of 10% and 200 feet long. Chart I shows Dayton in R-150. Examination of subsoil material - determines it is a clay loam with glacial till origin. Table I subsoil material glacial till and clay loam, K value is .32. Table II with R-150, K-.32, slope 10% and length of slope 200 feet. Soil loss in tons per acre per year is 91.

For additional information on soils in your area consult your local Soil Conservation Service office.

TABLE I
ESTIMATED K VALUES FOR GENERALIZED SOIL CATEGORIES IN OHIO

When Topsoil is Undisturbed

Generalized Soil Category (Texture of Topsoil)	Estimated K Value of Exposed Topsoil Material:
A. Silt Loam	.37
B. Loam	.32
C. Silty Clay Loam	.49
D. Sandy Loam	.24
E. Silty Clay or Clay	.43

When Subsoils are Exposed

Generalized Soil Category (Texture of Materials)	Estimated K Value of Exposed Subsoil Material:
A. Outwash Soils	
Sand	.17
Loamy Sand	.24
Sandy Loam	.43
Gravel, fine to mod. fine subsoil	.24
Gravel, med. to mod. coarse subsoil	.49
B. Lacustrine Soils	
Silt loam and v.f. sandy loam	.37
Silty clay loam	.28
Clay and silty clay	.28
C. Glacial till	
Loam, fine to mod. fine subsoil	.32
Loam, med. subsoil	.37
Clay loam	.32
Clay and silty clay	.28
D. Loess	.37
E. Residual	
Sandstone	.49
Siltstone, nonchannery	.43
Siltstone, channery	.32
Acid clay shale	.28
Calcareous clay shale or limestone residuum	.24

CHART I

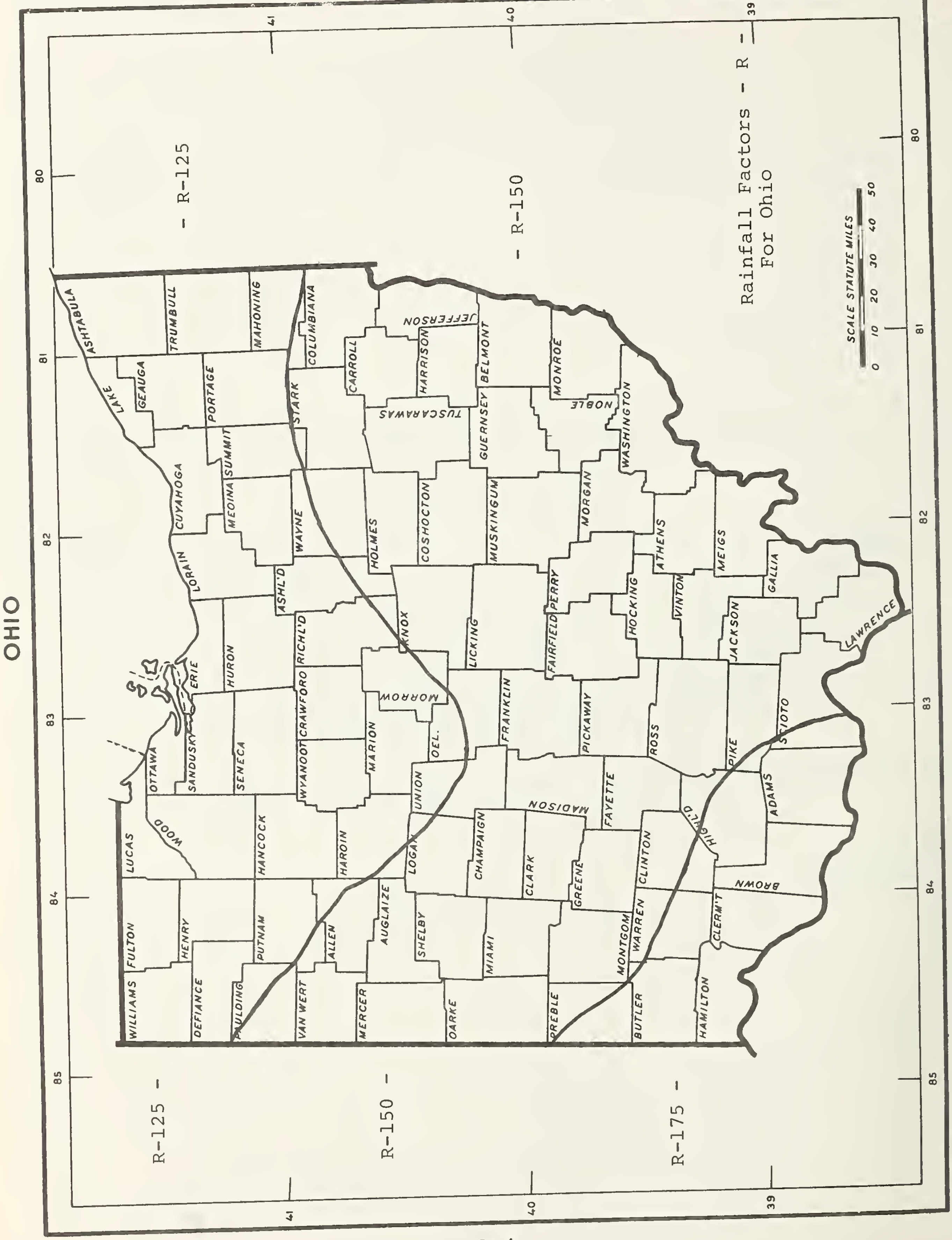


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TABLE II

POTENTIAL SEDIMENT PRODUCTION (A) FROM SHEET EROSION ON EXPOSED SOIL - TONS PER ACRE PER YEAR (A = KLS)

R = 125, K = .17

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	3	4	5	6	8
4	7	9	11	12	15
6	11	14	18	20	24
8	16	21	26	29	37
10	23	29	36	42	50
12	30	38	48	56	67
16	48	63	77	83	111
20	69	88	110	126	154
25	100	131	160	185	226
30	140	181	221	256	313
35	185	239	292	338	414
40	236	305	373	431	528
45	294	379	464	536	657
50	358	462	565	653	800

R = 125, K = .24

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	5	6	8	9	11
4	10	12	15	18	21
6	15	20	24	29	35
8	23	29	37	42	53
10	32	42	50	59	71
12	42	56	67	77	91
16	67	83	111	125	142
20	98	125	156	178	217
25	141	185	227	261	319
30	198	255	312	360	442
35	261	337	413	477	584
40	334	431	527	609	746
45	415	536	655	757	928
50	504	652	798	921	1129

R = 125, K = .28

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	6	7	9	10	13
4	11	14	18	20	25
6	18	23	29	33	40
8	27	34	42	50	59
10	37	48	59	67	83
12	50	63	77	91	111
16	77	100	125	143	167
20	114	145	182	208	253
25	165	215	264	304	373
30	231	298	364	421	516
35	305	393	482	556	682
40	389	502	615	711	870
45	484	625	765	884	1082
50	589	760	931	1075	1317

R - 125, K = .32

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	6	8	10	17	21
4	13	16	20	23	29
6	21	27	33	38	48
8	30	40	48	56	67
10	43	56	67	77	100
12	56	71	91	100	125
16	91	111	143	167	200
20	130	166	208	237	289
25	189	246	303	348	426
30	264	340	416	481	589
35	348	450	550	636	779
40	445	574	703	812	995
45	553	714	874	1010	1237
50	673	869	1054	1229	1506

R = 125, K = .37

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	8	10	12	14	17
4	15	19	23	27	33
6	24	31	38	43	53
8	36	45	56	67	77
10	50	63	77	91	111
12	67	83	100	125	143
16	100	143	167	200	250
20	150	192	240	274	334
25	218	284	348	402	493
30	305	393	482	556	682
35	403	520	636	735	901
40	514	664	813	939	1150
45	639	826	1011	1168	1430
50	778	1005	1230	1421	1741

R = 125, K = .43

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	9	10	14	16	20
4	17	22	27	31	38
6	28	36	43	50	63
8	42	53	67	77	91
10	59	71	91	100	125
12	77	100	125	143	167
16	125	167	200	200	250
20	175	223	279	319	389
25	253	331	405	468	573
30	354	457	560	647	792
35	468	604	740	854	1047
40	598	771	945	1091	1337
45	743	959	1171	1357	1662
50	905	1168	1429	1651	2023

R = 125, K = .49

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	10	13	16	18	22
4	19	25	31	36	43
6	32	40	50	59	71
8	48	53	77	83	111
10	67	83	100	125	143
12	83	111	143	167	200
16	143	167	200	250	333
20	199	254	318	363	443
25	289	377	461	533	653
30	404	521	638	737	903
35	533	689	843	974	1193
40	681	879	1076	1243	1523
45	847	1093	1338	1546	1894
50	1031	1331	1629	1882	2305

R = 125, K = .55

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	11	14	18	20	25
4	22	29	34	40	48
6	36	37	55	67	77
8	53	67	83	91	125
10	71	91	111	143	167
12	91	111	125	167	200
16	143	200	200	250	333
20	223	285	357	408	497
25	324	423	518	598	733
30	453	585	716	827	1013
35	599	773	946	1093	1339
40	765	967	1208	1396	1710
45	951	1227	1502	1736	2126
50	1157	1494	1828	2112	2588

SCS, Columbus, Ohio 8/30/69

POTENTIAL SEDIMENT PRODUCTION (A) FROM SHEET EROSION ON EXPOSED SOIL - TONS PER ACRE PER YEAR (A = KLS)

R = 150, K = .17

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	4	5	7	8	9
4	8	10	13	15	18
6	13	17	21	24	29
8	20	25	31	36	43
10	27	34	43	50	63
12	36	45	56	67	83
16	56	71	91	100	125
20	83	106	132	151	184
25	120	157	192	222	272
30	168	217	266	307	376
35	222	287	351	405	497
40	284	366	448	518	634
45	353	455	557	644	789
50	429	554	678	783	960

R = 150, K = .24

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	6	8	9	11	13
4	11	15	18	21	26
6	19	24	29	34	42
8	28	36	43	50	53
10	38	50	59	71	83
12	50	67	83	100	111
16	83	100	125	143	167
20	117	149	187	213	260
25	170	221	271	313	384
30	237	306	375	433	530
35	313	405	495	572	701
40	400	517	633	731	893
45	498	643	787	909	1113
50	606	732	957	1106	1355

R = 150, K = .28

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	7	9	11	13	15
4	13	17	21	24	30
6	22	29	31	40	50
8	32	42	50	67	71
10	45	59	71	83	100
12	59	77	91	111	125
16	91	125	143	167	200
20	137	174	218	249	304
25	198	258	316	365	448
30	277	357	437	505	619
35	366	472	578	668	818
40	467	603	738	853	1044
45	581	750	918	1060	1299
50	707	912	1117	1290	1581

R = 150, K = .32

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	8	10	12	14	18
4	15	20	24	28	34
6	25	32	40	45	56
8	37	48	59	67	83
10	50	67	83	91	111
12	67	91	111	125	143
16	111	143	167	200	250
20	156	199	249	285	347
25	226	295	361	418	511
30	316	408	498	577	707
35	418	540	660	763	935
40	534	689	844	974	1194
45	664	857	1049	1212	1484
50	808	1043	1277	1475	1807

R = 150, K = .37

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	9	12	14	16	20
4	18	23	28	32	40
6	29	37	45	53	67
8	43	56	67	77	100
10	59	77	91	111	125
12	77	100	125	143	167
16	125	167	200	250	250
20	180	230	288	329	402
25	262	341	418	483	591
30	366	472	578	668	818
35	483	624	754	882	1081
40	617	796	975	1127	1380
45	767	991	1213	1401	1716
50	934	1206	1476	1705	2089

R = 150, K = .43

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	10	14	17	19	23
4	20	25	32	37	45
6	33	43	53	63	77
8	50	63	77	91	111
10	57	91	111	125	167
12	91	111	143	167	200
16	143	200	250	250	333
20	210	268	335	382	467
25	304	397	486	561	687
30	425	549	572	776	950
35	562	725	888	1025	1256
40	717	925	1133	1309	1604
45	892	1151	1409	1628	1995
50	1085	1401	1715	1982	2428

R = 150, K = .49

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	12	15	19	22	27
4	23	30	37	43	53
6	38	50	59	71	83
8	56	71	91	100	125
10	77	100	125	143	167
12	100	143	167	200	250
16	167	200	250	333	333
20	239	305	381	436	532
25	347	452	553	639	783
30	484	625	765	884	1083
35	640	826	1011	1168	1431
40	817	1055	1292	1492	1828
45	1016	1312	1606	1855	2273
50	1237	1597	1955	2258	2766

R = 150, K = .55

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	13	17	21	24	30
4	26	34	42	48	59
6	43	56	67	77	91
8	63	83	100	111	143
10	83	111	143	167	200
12	111	143	167	200	250
16	167	200	250	333	333
20	268	342	428	489	597
25	389	507	621	718	879
30	544	702	859	992	1216
35	718	927	1135	1312	1607
40	917	1184	1450	1675	2052
45	1141	1473	1803	2083	2551
50	1388	1792	2194	2535	3105

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TABLE II

POTENTIAL SEDIMENT PRODUCTION (A) FROM SHEET EROSION ON EXPOSED SOIL - TONS PER ACRE PER YEAR (A = KLS)

R = 175, K = .17

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	5	6	8	9	11
4	9	12	15	17	21
6	15	20	24	29	34
8	23	29	35	42	50
10	31	42	50	59	71
12	42	53	67	77	91
16	67	83	100	125	143
20	97	123	154	176	215
25	140	183	224	259	317
30	196	253	310	358	438
35	259	334	409	473	579
40	331	427	523	604	740
45	411	531	650	751	920
50	501	646	791	914	1120

R = 175, K = .24

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	7	9	11	13	15
4	13	17	21	24	30
6	22	29	34	40	50
8	32	42	50	59	71
10	45	59	71	83	100
12	59	77	91	111	125
16	91	125	143	167	200
20	137	174	218	249	334
25	193	258	316	365	448
30	277	357	437	505	619
35	366	472	573	668	818
40	467	603	738	853	1045
45	581	750	918	1060	1299
50	707	912	1117	1290	1581

R = 175, K = .28

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	8	10	13	14	18
4	15	20	24	29	34
6	26	33	40	48	56
8	37	48	59	67	83
10	53	67	83	100	111
12	71	91	111	125	167
16	111	143	167	200	250
20	159	203	254	291	355
25	231	301	369	426	522
30	323	417	510	589	722
35	427	551	674	779	954
40	545	703	861	995	1219
45	678	875	1071	1237	1515
50	825	1065	1303	1506	1844

R = 175, K = .32

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	9	12	14	17	20
4	18	23	28	32	40
6	29	37	45	53	67
8	43	56	67	77	91
10	59	77	91	111	143
12	77	100	125	143	167
16	125	167	200	250	250
20	182	232	291	332	405
25	264	344	422	487	597
30	369	476	583	674	825
35	488	629	771	890	1091
40	623	804	984	1137	1393
45	774	1000	1224	1414	1732
50	942	1217	1489	1721	2108

R = 175, K = .37

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	11	14	17	19	24
4	20	26	32	37	45
6	33	43	53	63	77
8	50	63	77	91	111
10	71	91	111	125	167
12	91	125	143	167	200
16	143	200	250	250	333
20	210	269	336	384	468
25	305	398	488	563	690
30	427	551	674	779	954
35	564	728	891	1029	1261
40	720	929	1138	1315	1610
45	895	1156	1415	1635	2002
50	1090	1407	1722	1989	2437

R = 175, K = .43

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	12	16	19	22	28
4	24	31	38	43	53
6	38	50	63	71	91
8	59	77	91	111	125
10	83	91	125	143	167
12	111	143	167	200	250
16	167	200	250	333	333
20	245	312	391	446	544
25	355	463	567	655	802
30	496	640	784	905	1109
35	655	846	1035	1196	1465
40	637	1183	1322	1528	1871
45	1040	1343	1644	1900	2327
50	1266	1635	2001	2312	2832

R = 175, K = .49

Slope	Slope Length				
%	60'	100'	150'	200'	300'
2	14	18	22	26	31
4	28	36	43	50	63
6	45	59	71	83	100
8	67	83	100	125	143
10	91	125	143	167	200
12	125	143	200	200	250
16	200	250	333	333	500
20	279	356	445	508	620
25	404	527	646	746	914
30	565	729	893	1031	1264
35	747	964	1180	1363	1670
40	954	1231	1507	1741	2133
45	1186	1531	1874	2165	2652
50	1443	1863	2280	2635	3227

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TABLE III

FACTORS FOR CONVERTING SOIL (AIR DRY)
FROM TONS TO CUBIC YARDS PER ACRE

Sands, loamy sands - Multiply soil in tons/acre by .67 (110)[1/]

Sandy loam - Multiply soil in tons/acre by .70 (105)

Fine sandy loam - Multiply soil in tons/acre by .74 (100)

Loams, sandy clay loams, sandy clay - Multiply soil in tons/acre by .82 (90)

Silt loam - Multiply soil in tons/acre by .87 (85)

Silty clay loam, silty clay - Multiply soil in tons/acre by .92 (80)

Clay loam - Multiply soil in tons/acre by .98 (75)

Clay - Multiply soil in tons/acre by 1.06 (70)

1/ The number in parantheses is the air-dry weight of the soil per cubic foot and from which the conversion factors were calculated.

TABLE IV

Yearly Erosion Hazard Distribution

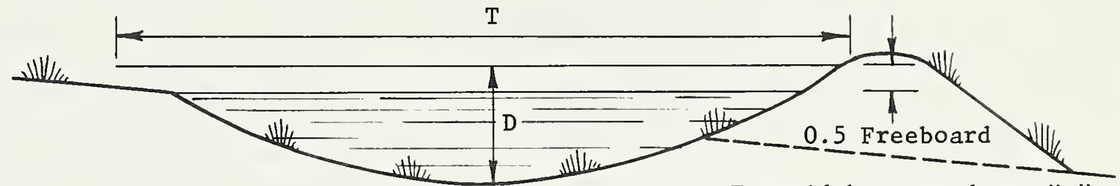
Date	Month	% of Annual Erosion Hazard	Erosion Rating	Yearly Accumulation Erosion %
2/1	January	1	Low	1
3/1	February	3	Low	4
4/1	March	3	Low	7
5/1	April	7	Mod.	14
6/1	May	10	Mod.	24
7/1	June	20	High	44
8/1	July	19	High	63
9/1	August	15	High	78
10/1	September	10	Mod.	88
11/1	October	6	Mod.	94
12/1	November	4	Low	98
1/1	December	2	Low	100

V_1 Based on Permissible Velocity of the Soil With Retardance "D"

Top Width, Depth & V_2 Based on Retardance "B"

Grade = 0.25%

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15																											
20																											
25	12	3.8	1.0																								
30	14	3.6	1.1																								
35	17	3.5	1.1																								
40	19	3.5	1.2	13	4.1	1.4																					
45	21	3.4	1.2	14	4.0	1.4																					
50	23	3.4	1.2	16	3.9	1.5																					
55	26	3.4	1.2	17	3.9	1.5																					
60	28	3.4	1.2	19	3.9	1.5																					
65	30	3.4	1.2	20	3.8	1.6																					
70	32	3.4	1.2	22	3.8	1.6	15	4.5	1.8																		
75	34	3.4	1.2	23	3.8	1.6	16	4.4	1.9																		
80	37	3.4	1.2	25	3.8	1.6	17	4.4	1.9																		
90	41	3.4	1.2	28	3.8	1.6	19	4.3	1.9																		
100	46	3.4	1.2	31	3.7	1.6	21	4.3	2.0																		
110	50	3.4	1.2	34	3.7	1.6	23	4.2	2.0																		
120	55	3.4	1.3	37	3.7	1.6	26	4.2	2.0	18	5.0	2.3															
130	59	3.4	1.3	40	3.7	1.6	28	4.2	2.0	19	4.9	2.4															
140	64	3.3	1.3	43	3.7	1.7	30	4.2	2.0	21	4.9	2.4															
150	68	3.3	1.3	46	3.7	1.7	32	4.2	2.0	22	4.8	2.5															
160	73	3.3	1.3	49	3.7	1.7	34	4.2	2.0	24	4.8	2.5															
170	77	3.3	1.3	52	3.7	1.7	36	4.2	2.1	25	4.8	2.5	20	5.5	2.8												
180	82	3.3	1.3	55	3.7	1.7	38	4.2	2.1	26	4.7	2.6	21	5.4	2.8												
190	86	3.3	1.3	58	3.7	1.7	40	4.2	2.1	28	4.7	2.6	22	5.4	2.8												
200	91	3.3	1.3	61	3.7	1.7	42	4.2	2.1	29	4.7	2.6	23	5.3	2.9												
220				67	3.7	1.7	46	4.2	2.1	32	4.7	2.6	25	5.3	2.9												
240				73	3.7	1.7	50	4.1	2.1	35	4.7	2.6	27	5.2	3.0												
260				79	3.7	1.7	54	4.1	2.1	38	4.7	2.6	29	5.2	3.0	22	6.0	3.3									
280				85	3.7	1.7	59	4.1	2.1	40	4.6	2.6	31	5.1	3.1	24	5.9	3.4									
300				91	3.7	1.7	63	4.1	2.1	43	4.6	2.7	33	5.1	3.1	26	5.9	3.4									



T = Top width, Retardance "B"
D = Depth, Retardance "B"
V_2 = Velocity, Retardance "B"
V_1 = Velocity, Retardance "D"

(Settlement to be added to top of ridge.)

Parabolic diversion design chart (Sheet 1 of 13)

V_1 Based on Permissible Velocity of the Soil With Retardance "D"

Top Width, Depth & V_2 Based on Retardance "B" Grade = 0.5%

Q	$V_1 = 2.0$			$V_1 = 2.5$			$V_1 = 3.0$			$V_1 = 3.5$			$V_1 = 4.0$			$V_1 = 4.5$			$V_1 = 5.0$			$V_1 = 5.5$			$V_1 = 6.0$		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	12	2.8	1.0																								
20	15	2.7	1.0																								
25	18	2.7	1.1	12	3.1	1.4																					
30	22	2.6	1.1	14	3.0	1.4	10	3.4	1.6																		
35	25	2.6	1.1	16	3.0	1.5	12	3.3	1.7																		
40	29	2.6	1.1	18	2.9	1.5	13	3.2	1.8																		
45	33	2.6	1.1	20	2.9	1.5	15	3.2	1.8																		
50	36	2.6	1.1	22	2.9	1.5	17	3.1	1.9	12	3.7	2.1															
55	40	2.6	1.1	24	2.9	1.6	18	3.1	1.9	13	3.6	2.2															
60	43	2.6	1.1	27	2.9	1.6	20	3.1	1.9	14	3.6	2.2															
65	47	2.6	1.1	29	2.9	1.6	21	3.1	1.9	15	3.5	2.3															
70	50	2.6	1.1	31	2.9	1.6	23	3.1	1.9	16	3.5	2.3															
75	54	2.6	1.1	33	2.9	1.6	25	3.1	1.9	17	3.5	2.3	14	4.0	2.5												
80	58	2.6	1.1	35	2.9	1.6	26	3.1	1.9	18	3.5	2.4	15	3.9	2.6												
90	65	2.6	1.1	40	2.9	1.6	29	3.1	2.0	21	3.5	2.4	16	3.9	2.6												
100	72	2.6	1.1	44	2.8	1.6	32	3.1	2.0	23	3.4	2.4	18	3.8	2.7	14	4.3	3.0									
110	79	2.6	1.1	48	2.8	1.6	36	3.1	2.0	25	3.4	2.4	20	3.8	2.8	16	4.2	3.1									
120	86	2.6	1.1	52	2.8	1.6	39	3.1	2.0	27	3.4	2.5	21	3.7	2.8	17	4.1	3.1									
130	93	2.6	1.1	57	2.8	1.6	42	3.1	2.0	30	3.4	2.5	23	3.7	2.8	18	4.1	3.2									
140				61	2.8	1.6	45	3.1	2.0	32	3.4	2.5	25	3.7	2.8	19	4.1	3.2									
150				65	2.8	1.6	48	3.1	2.0	34	3.4	2.5	26	3.7	2.9	21	4.1	3.2	17	4.6	3.5						
160				70	2.8	1.6	52	3.0	2.0	36	3.4	2.5	28	3.7	2.9	22	4.0	3.3	18	4.5	3.6						
170				74	2.8	1.6	55	3.0	2.0	39	3.4	2.5	30	3.7	2.9	24	4.0	3.3	19	4.5	3.6						
180				78	2.8	1.6	58	3.0	2.0	41	3.4	2.5	31	3.7	2.9	25	4.0	3.3	20	4.5	3.7						
190				83	2.8	1.6	61	3.0	2.0	43	3.4	2.5	33	3.7	2.9	26	4.0	3.3	21	4.5	3.7						
200				87	2.8	1.6	64	3.0	2.0	45	3.4	2.5	35	3.7	2.9	27	4.0	3.3	22	4.4	3.8	18	5.0	4.0			
220				95	2.8	1.6	71	3.0	2.0	50	3.4	2.5	38	3.7	2.9	30	4.0	3.4	24	4.4	3.8	19	4.9	4.1			
240							77	3.0	2.0	54	3.4	2.5	42	3.7	2.9	33	4.0	3.4	26	4.4	3.8	21	4.9	4.1			
260							83	3.0	2.0	59	3.4	2.5	45	3.7	3.0	36	4.0	3.4	28	4.3	3.9	23	4.8	4.2			
280							90	3.0	2.0	63	3.4	2.5	48	3.7	3.0	38	4.0	3.4	30	4.3	3.9	24	4.8	4.2	20	5.4	4.5
300							96	3.0	2.0	68	3.4	2.5	52	3.6	3.0	41	4.0	3.4	32	4.3	3.9	26	4.8	4.3	21	5.3	4.6

T = Top width, Retardance "B"
D = Depth, Retardance "B"
V_2 = Velocity, Retardance "B"
V_1 = Velocity, Retardance "D"

(Settlement to be added to top of ridge.)

Parabolic diversion design chart (Sheet 2 of 13)

V_1 Based on Permissible Velocity of the Soil With Retardance "D"

Top Width, Depth & V_2 Based on Retardance "B" Grade = 0.75%

Q	$V_1 = 2.0$			$V_1 = 2.5$			$V_1 = 3.0$			$V_1 = 3.5$			$V_1 = 4.0$			$V_1 = 4.5$			$V_1 = 5.0$			$V_1 = 5.5$			$V_1 = 6.0$		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	16	2.3	0.9	10	2.7	1.2																					
20	21	2.3	0.9	12	2.6	1.4																					
25	26	2.2	1.0	14	2.5	1.4	11	2.8	1.7																		
30	31	2.2	1.0	17	2.5	1.4	12	2.8	1.8	10	3.1	1.9															
35	36	2.2	1.0	20	2.5	1.5	14	2.7	1.8	11	3.0	2.1															
40	41	2.2	1.0	23	2.5	1.5	16	2.7	1.8	13	2.9	2.1															
45	46	2.2	1.0	26	2.5	1.5	18	2.7	1.9	14	2.9	2.2															
50	51	2.2	1.0	28	2.5	1.5	20	2.7	1.9	16	2.9	2.2	12	3.3	2.5												
55	56	2.2	1.0	31	2.5	1.5	22	2.7	1.9	17	2.9	2.2	13	3.3	2.5												
60	61	2.2	1.0	34	2.5	1.5	24	2.7	1.9	19	2.9	2.2	14	3.2	2.6												
65	66	2.2	1.0	37	2.5	1.5	26	2.6	1.9	20	2.8	2.3	15	3.2	2.6	12	3.5	2.8									
70	71	2.2	1.0	39	2.5	1.5	28	2.6	1.9	22	2.8	2.3	16	3.2	2.7	13	3.5	2.9									
75	76	2.2	1.0	42	2.5	1.5	30	2.6	1.9	23	2.8	2.3	17	3.2	2.7	14	3.5	2.9									
80	81	2.2	1.0	45	2.5	1.5	32	2.6	1.9	25	2.8	2.3	18	3.2	2.7	15	3.4	3.0									
90	91	2.2	1.0	50	2.5	1.5	36	2.6	1.9	28	2.8	2.3	20	3.1	2.8	16	3.4	3.1	13	3.8	3.3						
100				56	2.5	1.5	40	2.6	1.9	31	2.8	2.3	22	3.1	2.8	18	3.4	3.1	15	3.7	3.4						
110				61	2.5	1.5	44	2.6	1.9	34	2.8	2.3	25	3.1	2.8	20	3.3	3.2	16	3.7	3.5						
120				67	2.5	1.5	48	2.6	2.0	37	2.8	2.3	27	3.1	2.8	22	3.3	3.2	18	3.6	3.5	14	4.0	3.8			
130				72	2.5	1.5	52	2.6	2.0	40	2.8	2.3	29	3.1	2.9	23	3.3	3.2	19	3.6	3.6	16	4.0	3.8			
140				78	2.5	1.5	56	2.6	2.0	43	2.8	2.3	31	3.1	2.9	25	3.3	3.2	20	3.6	3.6	17	4.0	3.9			
150				83	2.5	1.6	60	2.6	2.0	46	2.8	2.3	33	3.1	2.9	27	3.3	3.2	22	3.6	3.7	18	3.9	4.0			
160				89	2.5	1.6	64	2.6	2.0	49	2.8	2.3	35	3.1	2.9	29	3.3	3.3	23	3.6	3.7	19	3.9	4.0	15	4.3	4.4
170				94	2.5	1.6	68	2.6	2.0	52	2.8	2.3	38	3.1	2.9	31	3.3	3.3	24	3.5	3.7	20	3.9	4.1	16	4.3	4.4
180							72	2.6	2.0	55	2.8	2.3	40	3.1	2.9	32	3.3	3.3	26	3.5	3.7	21	3.8	4.1	17	4.2	4.5
190							76	2.6	2.0	58	2.8	2.3	42	3.1	2.9	34	3.3	3.3	27	3.5	3.7	22	3.8	4.1	18	4.2	4.5
200							80	2.6	2.0	61	2.8	2.3	44	3.1	2.9	36	3.3	3.3	29	3.5	3.7	23	3.8	4.2	19	4.2	4.5
220							87	2.6	2.0	68	2.8	2.3	48	3.1	2.9	39	3.3	3.3	32	3.5	3.7	26	3.8	4.2	21	4.2	4.6
240							95	2.6	2.0	74	2.8	2.4	53	3.1	2.9	43	3.3	3.3	34	3.5	3.8	28	3.8	4.2	23	4.1	4.6
260										80	2.8	2.4	57	3.1	2.9	46	3.3	3.3	37	3.5	3.8	30	3.8	4.2	25	4.1	4.7
280										86	2.8	2.4	62	3.1	2.9	50	3.3	3.3	40	3.5	3.8	32	3.8	4.3	26	4.1	4.7
300										92	2.8	2.4	66	3.1	2.9	53	3.3	3.3	43	3.5	3.8	35	3.8	4.3	28	4.1	4.7

T = Top width, Retardance "B"
D = Depth, Retardance "B"
V_2 = Velocity, Retardance "B"
V_1 = Velocity, Retardance "D"

(Settlement to be added to top of ridge.)

Parabolic diversion design chart (Sheet 3 of 13)

V_1 Based on Permissible Velocity of the Soil With Retardance "D"

Grade = 1.0%

Top Width, Depth & V_2 Based on Retardance "B"

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	18	2.1	0.9	11	2.3	1.2																					
20	24	2.0	0.9	15	2.2	1.3	10	2.5	1.7																		
25	30	2.0	0.9	19	2.2	1.3	12	2.5	1.7	10	2.7	1.9															
30	36	2.0	0.9	22	2.2	1.4	15	2.4	1.8	12	2.6	2.0															
35	42	2.0	0.9	26	2.2	1.4	17	2.4	1.8	14	2.6	2.1	10	2.9	2.4												
40	48	2.0	1.0	29	2.2	1.4	19	2.4	1.8	15	2.5	2.1	12	2.8	2.5												
45	54	2.0	1.0	33	2.2	1.4	22	2.4	1.8	17	2.5	2.1	13	2.8	2.5												
50	59	2.0	1.0	37	2.2	1.4	24	2.4	1.9	19	2.5	2.2	14	2.8	2.5	11	3.1	2.9									
55	65	2.0	1.0	40	2.2	1.4	26	2.4	1.9	21	2.5	2.2	16	2.8	2.6	12	3.1	2.9									
60	71	2.0	1.0	44	2.2	1.4	29	2.4	1.9	23	2.5	2.2	17	2.7	2.6	13	3.0	3.0									
65	77	2.0	1.0	47	2.2	1.4	31	2.4	1.9	25	2.5	2.2	18	2.7	2.6	14	3.0	3.0	11	3.4	3.2						
70	83	2.0	1.0	51	2.2	1.4	33	2.4	1.9	26	2.5	2.2	20	2.7	2.6	15	3.0	3.0	12	3.3	3.3						
75	88	2.0	1.0	54	2.2	1.4	36	2.4	1.9	28	2.5	2.2	21	2.7	2.7	16	3.0	3.1	13	3.3	3.4						
80	94	2.0	1.0	58	2.2	1.4	38	2.4	1.9	30	2.5	2.2	23	2.7	2.7	17	3.0	3.1	14	3.2	3.4						
90				65	2.2	1.4	43	2.4	1.9	34	2.5	2.2	25	2.7	2.7	19	3.0	3.1	16	3.2	3.5	13	3.5	3.8			
100				72	2.2	1.4	47	2.4	1.9	38	2.5	2.2	28	2.7	2.7	21	3.0	3.1	17	3.2	3.6	14	3.4	3.9			
110				79	2.2	1.4	52	2.4	1.9	41	2.5	2.3	31	2.7	2.7	23	2.9	3.2	19	3.2	3.6	16	3.4	3.9	13	3.7	4.1
120				86	2.2	1.4	57	2.4	1.9	45	2.5	2.3	34	2.7	2.7	25	2.9	3.2	21	3.2	3.6	17	3.4	4.0	15	3.7	4.2
130				94	2.2	1.4	61	2.4	1.9	49	2.5	2.3	36	2.7	2.7	27	2.9	3.2	22	3.1	3.6	18	3.4	4.0	16	3.6	4.3
140							66	2.4	1.9	52	2.5	2.3	39	2.7	2.7	29	2.9	3.2	23	3.1	3.6	20	3.4	4.1	17	3.6	4.3
150							71	2.4	1.9	56	2.5	2.3	42	2.7	2.7	31	2.9	3.2	26	3.1	3.7	21	3.4	4.1	18	3.6	4.4
160							75	2.4	1.9	60	2.5	2.3	45	2.7	2.7	33	2.9	3.2	27	3.1	3.7	22	3.4	4.1	19	3.6	4.4
170							80	2.4	1.9	63	2.5	2.3	47	2.7	2.7	35	2.9	3.3	29	3.1	3.7	24	3.4	4.1	20	3.6	4.5
180							84	2.4	1.9	67	2.5	2.3	50	2.7	2.7	38	2.9	3.3	31	3.1	3.7	25	3.3	4.1	21	3.5	4.5
190							89	2.4	1.9	71	2.5	2.3	53	2.7	2.7	40	2.9	3.3	32	3.1	3.7	26	3.3	4.2	22	3.5	4.5
200							94	2.4	1.9	74	2.5	2.3	55	2.7	2.7	42	2.9	3.3	34	3.1	3.7	28	3.3	4.2	24	3.5	4.6
220										82	2.5	2.3	61	2.7	2.7	46	2.9	3.3	37	3.1	3.7	30	3.3	4.2	26	3.5	4.6
240										89	2.5	2.3	66	2.7	2.8	50	2.9	3.3	41	3.1	3.7	33	3.3	4.2	28	3.5	4.6
260										96	2.5	2.3	72	2.7	2.8	54	2.9	3.3	44	3.1	3.8	36	3.3	4.2	30	3.5	4.7
280													77	2.7	2.8	58	2.9	3.3	47	3.1	3.8	38	3.3	4.2	33	3.5	4.7
300													83	2.7	2.8	62	2.9	3.3	50	3.1	3.8	41	3.3	4.2	35	3.5	4.7

T = Top width, Retardance "B"
D = Depth, Retardance "B"
V_2 = Velocity, Retardance "B"
V_1 = Velocity, Retardance "D"

(Settlement to be added to top of ridge.)

Parabolic diversion design chart (Sheet 4 of 13)

V_1 Based on Permissible Velocity of the Soil With Retardance "D"

Top Width, Depth & V_2 Based on Retardance "B"

Grade = 1.5%

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	24	1.8	0.9	15	1.9	1.2	10	2.2	1.5																		
20	32	1.8	0.9	20	1.9	1.2	14	2.1	1.6																		
25	39	1.8	0.9	25	1.9	1.2	17	2.1	1.6	11	2.3	2.1															
30	47	1.8	0.9	31	1.9	1.2	20	2.1	1.6	13	2.3	2.2	11	2.4	2.4												
35	55	1.8	0.9	36	1.9	1.2	23	2.1	1.7	16	2.2	2.2	13	2.4	2.5	10	2.6	2.7									
40	63	1.8	0.9	41	1.9	1.2	27	2.1	1.7	18	2.2	2.2	14	2.3	2.6	12	2.5	2.8									
45	70	1.8	0.9	46	1.9	1.2	30	2.1	1.7	20	2.2	2.2	16	2.3	2.6	13	2.5	2.8	10	2.8	3.2						
50	78	1.8	0.9	51	1.9	1.2	33	2.1	1.7	22	2.2	2.2	18	2.3	2.6	15	2.5	2.9	11	2.8	3.3						
55	86	1.8	0.9	55	1.9	1.2	36	2.1	1.7	24	2.2	2.3	20	2.3	2.6	16	2.5	2.9	12	2.7	3.4	10	3.0	3.5			
60	93	1.8	0.9	60	1.9	1.2	40	2.0	1.7	26	2.2	2.3	21	2.3	2.6	17	2.5	2.9	13	2.7	3.4	11	3.0	3.6			
65				65	1.9	1.2	43	2.0	1.7	29	2.2	2.3	23	2.3	2.6	19	2.5	3.0	14	2.7	3.4	12	2.9	3.7			
70				70	1.9	1.2	46	2.0	1.7	31	2.2	2.3	25	2.3	2.6	20	2.5	3.0	15	2.7	3.4	13	2.9	3.8	11	3.1	4.0
75				75	1.9	1.2	49	2.0	1.7	33	2.2	2.3	26	2.3	2.7	22	2.5	3.0	16	2.7	3.5	14	2.9	3.8	12	3.1	4.0
80				80	1.9	1.2	52	2.0	1.7	35	2.2	2.3	28	2.3	2.7	23	2.5	3.0	18	2.7	3.5	15	2.9	3.8	13	3.1	4.2
90				90	1.9	1.2	59	2.0	1.7	39	2.2	2.3	32	2.3	2.7	26	2.5	3.0	20	2.7	3.5	16	2.8	3.9	14	3.0	4.2
100							65	2.0	1.7	44	2.2	2.3	35	2.3	2.7	29	2.4	3.0	22	2.7	3.5	18	2.8	4.0	15	3.0	4.3
110							72	2.0	1.7	48	2.2	2.3	39	2.3	2.7	31	2.4	3.0	24	2.7	3.5	20	2.8	4.0	17	3.0	4.4
120							78	2.0	1.7	52	2.2	2.3	42	2.3	2.7	34	2.4	3.0	26	2.6	3.6	22	2.8	4.0	18	3.0	4.4
130							85	2.0	1.7	57	2.2	2.3	45	2.3	2.7	37	2.4	3.0	28	2.6	3.6	23	2.8	4.0	19	3.0	4.4
140							91	2.0	1.7	61	2.2	2.3	49	2.3	2.7	40	2.4	3.1	30	2.6	3.6	25	2.8	4.0	21	3.0	4.5
150							97	2.0	1.7	65	2.2	2.3	52	2.3	2.7	43	2.4	3.1	32	2.6	3.6	27	2.8	4.0	22	2.9	4.5
160										69	2.2	2.3	56	2.3	2.7	45	2.4	3.1	34	2.6	3.6	29	2.8	4.1	24	2.9	4.5
170										74	2.2	2.3	59	2.3	2.7	48	2.4	3.1	37	2.6	3.6	30	2.8	4.1	25	2.9	4.5
180										78	2.2	2.3	63	2.3	2.7	51	2.4	3.1	39	2.6	3.6	32	2.8	4.1	27	2.9	4.6
190										82	2.2	2.3	66	2.3	2.7	54	2.4	3.1	41	2.6	3.7	34	2.8	4.1	28	2.9	4.6
200										86	2.2	2.3	69	2.3	2.7	56	2.4	3.1	43	2.6	3.7	36	2.8	4.1	30	2.9	4.6
220										95	2.2	2.3	76	2.3	2.7	62	2.4	3.1	47	2.6	3.7	39	2.8	4.1	33	2.9	4.6
240													83	2.3	2.7	68	2.4	3.1	51	2.6	3.7	43	2.8	4.1	35	2.9	4.6
260													90	2.3	2.7	73	2.4	3.1	55	2.6	3.7	46	2.8	4.1	38	2.9	4.6
280													97	2.3	2.7	79	2.4	3.1	60	2.6	3.7	50	2.8	4.1	41	2.9	4.6
300																84	2.4	3.1	64	2.6	3.7	53	2.8	4.1	44	2.9	4.7

T = Top width, Retardance "B"
D = Depth, Retardance "B"
V_2 = Velocity, Retardance "B"
V_1 = Velocity, Retardance "D"

(Settlement to be added to top of ridge.)

Parabolic diversion design chart (Sheet 5 of 13)

V_1 Based on Permissible Velocity of the Soil With Retardance "D"

Top Width, Depth & V_2 Based on Retardance "B" Grade = 2.0%

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	30	1.6	0.8	18	1.8	1.2	13	1.9	1.4	9	2.1	1.8															
20	39	1.6	0.8	24	1.8	1.2	17	1.9	1.5	12	2.0	1.9															
25	49	1.6	0.8	30	1.7	1.2	21	1.9	1.5	15	2.0	2.0	11	2.2	2.4												
30	59	1.6	0.8	35	1.7	1.2	25	1.9	1.5	18	2.0	2.0	13	2.1	2.5	10	2.3	2.8									
35	68	1.6	0.8	41	1.7	1.2	29	1.9	1.5	21	2.0	2.0	15	2.1	2.5	12	2.2	2.9	10	2.4	3.0						
40	78	1.6	0.8	47	1.7	1.2	34	1.9	1.5	23	2.0	2.0	17	2.1	2.5	14	2.2	2.9	11	2.4	3.2						
45	88	1.6	0.8	53	1.7	1.2	38	1.9	1.5	26	2.0	2.0	19	2.1	2.5	15	2.2	2.9	13	2.4	3.2	10	2.6	3.5			
50	97	1.6	0.8	59	1.7	1.2	42	1.9	1.6	29	2.0	2.0	21	2.1	2.6	17	2.2	2.9	14	2.4	3.2	11	2.5	3.6			
55				64	1.7	1.2	46	1.8	1.6	32	2.0	2.0	23	2.1	2.6	19	2.2	2.9	15	2.4	3.3	12	2.5	3.7	10	2.7	4.0
60				70	1.7	1.2	50	1.8	1.6	35	2.0	2.0	25	2.1	2.6	20	2.2	3.0	17	2.4	3.3	13	2.5	3.7	11	2.7	4.0
65				76	1.7	1.2	54	1.8	1.6	38	2.0	2.0	27	2.1	2.6	22	2.2	3.0	18	2.3	3.4	15	2.5	3.7	12	2.7	4.1
70				81	1.7	1.2	58	1.8	1.6	41	2.0	2.1	29	2.1	2.6	24	2.2	3.0	19	2.3	3.4	16	2.5	3.8	13	2.7	4.1
75				87	1.7	1.2	62	1.8	1.6	43	2.0	2.1	31	2.1	2.6	25	2.2	3.0	21	2.3	3.4	17	2.5	3.8	14	2.7	4.1
80				93	1.7	1.2	68	1.8	1.6	46	2.0	2.1	33	2.1	2.6	27	2.2	3.0	22	2.3	3.4	18	2.5	3.8	15	2.6	4.2
90							74	1.8	1.6	52	2.0	2.1	37	2.1	2.6	30	2.2	3.0	25	2.3	3.4	20	2.5	3.8	17	2.6	4.2
100							83	1.8	1.6	58	2.0	2.1	41	2.1	2.6	34	2.2	3.0	27	2.3	3.4	22	2.5	3.9	18	2.6	4.3
110							91	1.8	1.6	63	2.0	2.1	45	2.1	2.6	37	2.2	3.0	30	2.3	3.4	24	2.5	3.9	20	2.6	4.3
120							99	1.8	1.6	69	2.0	2.1	49	2.1	2.6	40	2.2	3.0	33	2.3	3.4	26	2.4	3.9	22	2.6	4.3
130										75	2.0	2.1	53	2.1	2.6	44	2.2	3.0	35	2.3	3.4	29	2.4	3.9	24	2.6	4.3
140										80	2.0	2.1	57	2.1	2.6	47	2.2	3.0	38	2.3	3.5	31	2.4	3.9	26	2.6	4.4
150										86	2.0	2.1	61	2.1	2.7	50	2.2	3.0	41	2.3	3.5	33	2.4	3.9	27	2.6	4.4
160										91	2.0	2.1	65	2.1	2.7	53	2.2	3.0	43	2.3	3.5	35	2.4	3.9	29	2.6	4.4
170										97	2.0	2.1	69	2.1	2.7	57	2.2	3.1	46	2.3	3.5	37	2.4	4.0	31	2.6	4.4
180													73	2.1	2.7	60	2.2	3.1	49	2.3	3.5	39	2.4	4.0	33	2.6	4.4
190													77	2.1	2.7	63	2.2	3.1	51	2.3	3.5	41	2.4	4.0	34	2.6	4.5
200													81	2.1	2.7	66	2.2	3.1	54	2.3	3.5	44	2.4	4.0	36	2.6	4.5
220													89	2.1	2.7	73	2.2	3.1	59	2.3	3.5	48	2.4	4.0	40	2.6	4.5
240													97	2.1	2.7	79	2.2	3.1	65	2.3	3.5	52	2.4	4.0	43	2.6	4.5
260																86	2.2	3.1	70	2.3	3.5	56	2.4	4.0	47	2.6	4.5
280																92	2.2	3.1	75	2.3	3.5	61	2.4	4.0	50	2.6	4.5
300																99	2.2	3.1	81	2.3	3.5	65	2.4	4.0	54	2.6	4.5

T = Top width, Retardance "B"
D = Depth, Retardance "B"
V_2 = Velocity, Retardance "B"
V_1 = Velocity, Retardance "D"

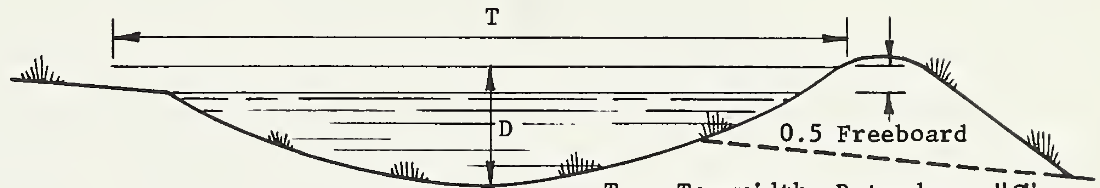
(Settlement to be added to top of ridge.)

Parabolic diversion design chart (Sheet 6 of 13)

V_1 Based on Permissible Velocity of the Soil With Retardance "D"

Top Width, Depth & V_2 Based on Retardance "C" Grade = 0.25%

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15																											
20																											
25	11	2.9	1.6																								
30	13	2.8	1.7																								
35	15	2.8	1.7																								
40	17	2.8	1.8	11	3.2	2.1																					
45	19	2.7	1.8	13	3.1	2.2																					
50	21	2.7	1.8	14	3.1	2.2																					
55	23	2.7	1.8	15	3.1	2.3																					
60	25	2.7	1.8	17	3.0	2.3																					
65	27	2.7	1.8	18	3.0	2.3																					
70	29	2.7	1.9	19	3.0	2.3	14	3.6	2.7																		
75	31	2.7	1.9	21	3.0	2.3	15	3.5	2.8																		
80	33	2.7	1.9	22	3.0	2.4	16	3.5	2.8																		
90	37	2.7	1.9	25	3.0	2.4	17	3.5	2.8																		
100	41	2.7	1.9	28	3.0	2.4	19	3.5	2.9																		
110	45	2.7	1.9	30	3.0	2.4	21	3.4	2.9																		
120	49	2.7	1.9	33	3.0	2.4	23	3.4	2.9	16	4.1	3.3															
130	53	2.7	1.9	36	3.0	2.4	25	3.4	2.9	18	4.1	3.3															
140	57	2.7	1.9	38	3.0	2.4	27	3.4	2.9	19	4.0	3.4															
150	61	2.7	1.9	41	3.0	2.4	29	3.4	2.9	20	4.0	3.4															
160	65	2.7	1.9	44	3.0	2.4	30	3.4	3.0	21	4.0	3.4															
170	69	2.7	1.9	46	3.0	2.4	32	3.4	3.0	23	4.0	3.4	18	4.5	3.8												
180	73	2.7	1.9	49	3.0	2.4	34	3.4	3.0	24	4.0	3.5	19	4.5	3.8												
190	77	2.7	1.9	52	3.0	2.4	36	3.4	3.0	25	4.0	3.5	20	4.5	3.9												
200	81	2.7	1.9	55	3.0	2.4	38	3.4	3.0	27	3.9	3.5	21	4.4	3.9												
220	89	2.7	1.9	60	3.0	2.4	42	3.4	3.0	29	3.9	3.5	23	4.4	3.9												
240	97	2.7	1.9	65	3.0	2.5	45	3.4	3.0	32	3.9	3.6	25	4.4	4.0												
260				71	3.0	2.5	49	3.4	3.0	34	3.9	3.6	27	4.4	4.0	21	5.1	4.3									
280				76	3.0	2.5	53	3.4	3.0	37	3.9	3.6	29	4.4	4.0	22	5.1	4.3									
300				82	3.0	2.5	57	3.4	3.0	40	3.9	3.6	31	4.3	4.1	24	5.0	4.4									



T = Top width, Retardance "C"
D = Depth, Retardance "C"
V_2 = Velocity, Retardance "C"
V_1 = Velocity, Retardance "D"

(Settlement to be added to top of ridge.)

Parabolic diversion design chart (Sheet 7 of 13)

V_1 Based on Permissible Velocity of the Soil With Retardance "D"

Top Width, Depth & V_2 Based on Retardance "C" Grade = 0.5%

Q	$V_1 = 2.0$			$V_1 = 2.5$			$V_1 = 3.0$			$V_1 = 3.5$			$V_1 = 4.0$			$V_1 = 4.5$			$V_1 = 5.0$			$V_1 = 5.5$			$V_1 = 6.0$		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	10	2.1	1.6																								
20	13	2.1	1.7																								
25	16	2.1	1.7	10	2.4	2.1																					
30	20	2.1	1.7	12	2.4	2.2	9	2.7	2.5																		
35	23	2.1	1.7	14	2.4	2.3	11	2.6	2.6																		
40	26	2.1	1.7	16	2.3	2.3	12	2.6	2.7																		
45	29	2.0	1.7	18	2.3	2.3	13	2.5	2.8																		
50	32	2.0	1.7	20	2.3	2.4	15	2.5	2.8	11	2.9	3.2															
55	35	2.0	1.7	22	2.3	2.4	16	2.5	2.8	12	2.9	3.3															
60	39	2.0	1.7	24	2.3	2.4	18	2.5	2.8	13	2.9	3.3															
65	42	2.0	1.8	26	2.3	2.4	19	2.5	2.9	14	2.9	3.3															
70	45	2.0	1.8	28	2.3	2.4	21	2.5	2.9	15	2.8	3.4															
75	48	2.0	1.8	30	2.3	2.4	22	2.5	2.9	16	2.8	3.4	12	3.2	3.7												
80	51	2.0	1.8	32	2.3	2.4	23	2.5	2.9	17	2.8	3.4	13	3.2	3.8												
90	57	2.0	1.8	35	2.3	2.4	26	2.5	2.9	19	2.8	3.4	15	3.2	3.8												
100	64	2.0	1.8	39	2.3	2.4	29	2.5	2.9	21	2.8	3.5	16	3.1	3.9	13	3.5	4.1									
110	70	2.0	1.8	43	2.3	2.4	32	2.5	2.9	23	2.8	3.5	18	3.1	3.9	14	3.5	4.2									
120	76	2.0	1.8	47	2.3	2.4	35	2.5	2.9	25	2.8	3.5	19	3.1	3.9	15	3.4	4.3									
130	83	2.0	1.8	51	2.3	2.4	38	2.5	2.9	27	2.8	3.5	21	3.1	4.0	17	3.4	4.4									
140	89	2.0	1.8	55	2.3	2.4	41	2.5	2.9	29	2.8	3.5	22	3.1	4.0	18	3.4	4.3									
150	95	2.0	1.8	59	2.3	2.4	44	2.5	2.9	31	2.8	3.5	24	3.1	4.0	19	3.4	4.4	15	3.8	4.8						
160				62	2.3	2.4	46	2.5	2.9	33	2.8	3.5	25	3.1	4.0	20	3.4	4.4	16	3.8	4.8						
170				66	2.3	2.4	49	2.5	2.9	35	2.8	3.6	27	3.1	4.0	22	3.4	4.4	17	3.8	4.9						
180				70	2.3	2.4	52	2.5	2.9	37	2.8	3.6	29	3.1	4.0	23	3.4	4.5	18	3.8	4.9						
190				74	2.3	2.4	55	2.5	2.9	39	2.8	3.6	30	3.1	4.0	24	3.4	4.5	19	3.8	5.0						
200				78	2.3	2.4	58	2.5	2.9	41	2.8	3.6	32	3.1	4.0	25	3.4	4.5	20	3.8	5.0	16	4.2	5.2			
220				86	2.3	2.4	64	2.5	2.9	45	2.8	3.6	35	3.1	4.0	28	3.4	4.5	22	3.7	5.0	18	4.2	5.3			
240				93	2.3	2.4	69	2.5	2.9	49	2.8	3.6	38	3.0	4.1	30	3.4	4.5	24	3.7	5.0	20	4.2	5.4			
260							75	2.5	2.9	53	2.8	3.6	41	3.0	4.1	33	3.4	4.5	26	3.7	5.0	21	4.1	5.4			
280							81	2.5	3.0	57	2.8	3.6	44	3.0	4.1	35	3.3	4.6	28	3.7	5.0	23	4.1	5.5	19	4.6	5.8
300							87	2.5	3.0	61	2.8	3.6	47	3.0	4.1	38	3.3	4.6	30	3.6	5.0	24	4.1	5.5	20	4.6	5.8

T = Top Width, Retardance "C"
D = Depth, Retardance "C"
V_2 = Velocity, Retardance "C"
V_1 = Velocity, Retardance "D"

(Settlement to be added to top of ridge.)

Parabolic diversion design chart (Sheet 8 of 13)

V_1 Based on Permissible Velocity of the Soil With Retardance "D"

Top Width, Depth & V_2 Based on Retardance "C"

Grade = 0.75%

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	14	1.8	1.5																								
20	18	1.8	1.5	10	2.0	2.2																					
25	23	1.8	1.5	13	2.0	2.2																					
30	27	1.8	1.5	15	2.0	2.2	11	2.2	2.7																		
35	32	1.8	1.5	18	2.0	2.3	13	2.2	2.7	10	2.4	3.1															
40	37	1.8	1.5	20	2.0	2.3	15	2.2	2.8	11	2.4	3.2															
45	41	1.8	1.6	23	2.0	2.3	17	2.2	2.8	13	2.3	3.2															
50	45	1.8	1.6	25	2.0	2.3	18	2.1	2.9	14	2.3	3.3	10	2.7	3.7												
55	50	1.8	1.6	28	2.0	2.3	20	2.1	2.9	16	2.3	3.3	11	2.6	3.8												
60	54	1.8	1.6	30	2.0	2.3	22	2.1	2.9	17	2.3	3.3	12	2.6	3.8												
65	59	1.8	1.6	33	2.0	2.3	24	2.1	2.9	18	2.3	3.3	13	2.6	3.8	11	2.9	4.1									
70	63	1.8	1.6	35	2.0	2.3	25	2.1	2.9	20	2.3	3.3	14	2.6	3.9	12	2.9	4.2									
75	68	1.8	1.6	38	2.0	2.3	27	2.1	2.9	21	2.3	3.3	15	2.6	3.9	13	2.8	4.2									
80	72	1.8	1.6	40	2.0	2.3	29	2.1	2.9	23	2.3	3.3	16	2.6	3.9	14	2.8	4.3									
90	81	1.8	1.6	45	2.0	2.3	33	2.1	2.9	25	2.3	3.4	18	2.6	4.0	15	2.8	4.4	12	3.1	4.6						
100	90	1.8	1.6	50	2.0	2.3	36	2.1	2.9	28	2.3	3.4	20	2.6	4.0	17	2.8	4.4	13	3.1	4.8						
110	99	1.8	1.6	55	2.0	2.3	40	2.1	2.9	31	2.3	3.4	22	2.5	4.0	18	2.8	4.5	15	3.1	4.8						
120				60	2.0	2.3	43	2.1	2.9	34	2.3	3.4	24	2.5	4.0	20	2.8	4.5	16	3.0	4.8	13	3.4	5.2			
130				65	2.0	2.4	47	2.1	2.9	36	2.3	3.4	26	2.5	4.0	21	2.7	4.5	17	3.0	4.9	14	3.3	5.3			
140				70	2.0	2.4	50	2.1	2.9	39	2.3	3.4	28	2.5	4.1	23	2.7	4.5	19	3.0	4.9	15	3.3	5.3			
150				75	2.0	2.4	54	2.1	2.9	42	2.3	3.4	30	2.5	4.1	25	2.7	4.5	20	3.0	4.9	16	3.3	5.3			
160				80	2.0	2.4	58	2.1	2.9	45	2.3	3.4	32	2.5	4.1	26	2.7	4.5	21	3.0	4.9	17	3.3	5.4	14	3.6	5.8
170				85	2.0	2.4	61	2.1	2.9	47	2.3	3.4	34	2.5	4.1	28	2.7	4.5	22	3.0	5.0	18	3.3	5.4	15	3.6	5.8
180				89	2.0	2.4	65	2.1	2.9	50	2.3	3.4	36	2.5	4.1	29	2.7	4.5	24	3.0	5.0	19	3.3	5.5	16	3.6	5.9
190				94	2.0	2.4	68	2.1	2.9	53	2.3	3.4	38	2.5	4.1	31	2.7	4.6	25	3.0	5.0	21	3.3	5.5	17	3.6	5.9
200				99	2.0	2.4	72	2.1	3.0	55	2.3	3.4	40	2.5	4.1	33	2.7	4.6	26	3.0	5.0	22	3.2	5.5	18	3.6	5.9
220							79	2.1	3.0	61	2.3	3.4	44	2.5	4.1	36	2.7	4.6	29	3.0	5.0	24	3.2	5.5	19	3.6	5.9
240							86	2.1	3.0	66	2.3	3.4	48	2.5	4.1	39	2.7	4.6	32	3.0	5.0	26	3.2	5.5	21	3.6	6.0
260							93	2.1	3.0	72	2.3	3.4	52	2.5	4.1	42	2.7	4.6	34	3.0	5.0	28	3.2	5.5	23	3.6	6.0
280										77	2.3	3.4	56	2.5	4.1	45	2.7	4.6	37	3.0	5.0	30	3.2	5.5	24	3.5	6.0
300										83	2.3	3.5	60	2.5	4.1	49	2.7	4.6	39	3.0	5.0	32	3.2	5.5	26	3.5	6.0

T = Top Width, Retardance "C"
D = Depth, Retardance "C"
V2 = Velocity, Retardance "C"
V_1 = Velocity, Retardance "D"

(Settlement to be added to top of ridge)

Parabolic diversion design chart (Sheet 9 of 13)

V_1 Based on Permissible Velocity of the Soil With Retardance "D"

Top Width, Depth & V_2 Based on Retardance "C" Grade = 1.0%

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	16	1.6	1.5	10	1.8	2.0																					
20	22	1.6	1.5	13	1.8	2.1																					
25	27	1.6	1.5	17	1.8	2.1	11	2.0	2.6																		
30	32	1.6	1.5	20	1.8	2.1	13	2.0	2.7	11	2.1	3.0															
35	37	1.6	1.5	23	1.8	2.2	15	2.0	2.8	12	2.1	3.1															
40	43	1.6	1.5	26	1.8	2.2	17	1.9	2.8	14	2.1	3.1	10	2.3	3.7												
45	48	1.6	1.5	29	1.8	2.2	19	1.9	2.8	16	2.1	3.2	12	2.3	3.7												
50	53	1.6	1.5	33	1.8	2.2	22	1.9	2.8	17	2.1	3.2	13	2.3	3.7	10	2.5	4.2									
55	58	1.6	1.5	36	1.8	2.2	24	1.9	2.8	19	2.0	3.3	14	2.3	3.8	11	2.5	4.3									
60	64	1.6	1.5	39	1.8	2.2	26	1.9	2.8	21	2.0	3.3	15	2.2	3.8	12	2.5	4.3									
65	69	1.6	1.5	42	1.8	2.2	28	1.9	2.8	22	2.0	3.3	17	2.2	3.8	13	2.5	4.3	10	2.7	4.7						
70	74	1.6	1.5	45	1.8	2.2	30	1.9	2.8	24	2.0	3.3	18	2.2	3.9	14	2.5	4.4	11	2.7	4.7						
75	79	1.6	1.5	49	1.8	2.2	32	1.9	2.9	26	2.0	3.3	19	2.2	3.9	15	2.5	4.5	12	2.7	4.7						
80	84	1.6	1.5	52	1.8	2.2	34	1.9	2.9	27	2.0	3.3	20	2.2	3.9	16	2.5	4.5	13	2.7	4.9						
90	95	1.6	1.5	58	1.8	2.2	38	1.9	2.9	31	2.0	3.3	23	2.2	3.9	17	2.4	4.5	14	2.7	4.9	12	2.9	5.2			
100				65	1.8	2.2	43	1.9	2.9	34	2.0	3.3	25	2.2	3.9	19	2.4	4.5	16	2.7	4.9	13	2.9	5.3			
110				71	1.8	2.2	47	1.9	2.9	37	2.0	3.3	28	2.2	3.9	21	2.4	4.5	17	2.6	5.0	14	2.9	5.3	12	3.1	5.7
120				77	1.8	2.2	51	1.9	2.9	41	2.0	3.3	30	2.2	4.0	23	2.4	4.5	19	2.6	5.0	16	2.9	5.4	13	3.1	5.7
130				84	1.8	2.2	55	1.9	2.9	44	2.0	3.3	33	2.2	4.0	25	2.4	4.5	20	2.6	5.0	17	2.9	5.4	14	3.1	5.8
140				90	1.8	2.2	59	1.9	2.9	47	2.0	3.3	35	2.2	4.0	27	2.4	4.5	22	2.6	5.0	18	2.8	5.5	15	3.1	5.8
150				96	1.8	2.2	64	1.9	2.9	51	2.0	3.3	38	2.2	4.0	29	2.4	4.5	23	2.6	5.0	19	2.8	5.5	17	3.1	5.8
160							68	1.9	2.9	54	2.0	3.3	40	2.2	4.0	30	2.4	4.5	25	2.6	5.0	20	2.8	5.5	18	3.0	6.0
170							72	1.9	2.9	57	2.0	3.3	43	2.2	4.0	32	2.4	4.5	26	2.5	5.0	22	2.8	5.5	19	3.0	6.0
180							76	1.9	2.9	61	2.0	3.4	45	2.2	4.0	34	2.4	4.5	28	2.6	5.0	23	2.8	5.5	20	3.0	6.0
190							80	1.9	2.9	64	2.0	3.4	48	2.2	4.0	36	2.4	4.5	29	2.6	5.0	24	2.8	5.5	21	3.0	6.0
200							84	1.9	2.9	67	2.0	3.4	50	2.2	4.0	38	2.4	4.5	31	2.6	5.0	25	2.8	5.5	22	3.0	6.0
220							93	1.9	2.9	74	2.0	3.4	55	2.2	4.0	42	2.4	4.5	34	2.6	5.0	28	2.8	5.5	24	3.0	6.0
240										81	2.0	3.4	60	2.2	4.0	45	2.4	4.5	37	2.6	5.0	30	2.8	5.5	26	3.0	6.0
260										87	2.0	3.4	65	2.2	4.0	49	2.4	4.5	40	2.6	5.0	33	2.8	5.5	28	3.0	6.0
280										94	2.0	3.4	70	2.2	4.0	53	2.4	4.5	43	2.6	5.0	36	2.8	5.5	30	3.0	6.0
300													75	2.2	4.0	57	2.4	4.5	46	2.5	5.0	38	2.8	5.5	32	3.0	6.0

T = Top Width, Retardance "C"
D = Depth, Retardance "C"
V_2 = Velocity, Retardance "C"
V_1 = Velocity, Retardance "D"

(Settlement to be added to top of ridge.)

Parabolic diversion design chart (Sheet 10 of 13)

V_1 Based on Permissible Velocity of the Soil With Retardance "D"

Top Width, Depth & V_2 Based on Retardance "C" Grade = 1.5%

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	21	1.4	1.4	14	1.6	1.9																					
20	28	1.4	1.4	18	1.5	1.9	12	1.7	2.5																		
25	35	1.4	1.4	23	1.5	1.9	15	1.7	2.6	10	1.9	3.2															
30	42	1.4	1.4	27	1.5	1.9	18	1.7	2.6	12	1.8	3.2	10	2.0	3.6												
35	49	1.4	1.4	32	1.5	2.0	21	1.6	2.6	14	1.8	3.3	11	1.9	3.7	10	2.1	4.1									
40	56	1.4	1.4	36	1.5	2.0	24	1.6	2.6	16	1.8	3.3	13	1.9	3.7	11	2.1	4.2									
45	63	1.4	1.4	41	1.5	2.0	27	1.6	2.6	18	1.8	3.4	15	1.9	3.8	12	2.0	4.3									
50	70	1.4	1.4	45	1.5	2.0	30	1.6	2.7	20	1.8	3.4	16	1.9	3.9	13	2.0	4.3	10	2.3	4.8						
55	76	1.4	1.5	50	1.5	2.0	33	1.6	2.7	22	1.8	3.4	18	1.9	3.9	14	2.0	4.3	11	2.3	4.9						
60	83	1.4	1.5	54	1.5	2.0	35	1.6	2.7	24	1.8	3.4	19	1.9	3.9	16	2.0	4.4	12	2.3	4.9	10	2.4	5.2			
65	90	1.4	1.5	58	1.5	2.0	38	1.6	2.7	26	1.8	3.4	21	1.9	3.9	17	2.0	4.4	13	2.2	5.0	11	2.4	5.3			
70	97	1.4	1.5	63	1.5	2.0	41	1.6	2.7	28	1.8	3.4	22	1.9	3.9	18	2.0	4.4	14	2.2	5.0	12	2.4	5.4	10	2.6	5.6
75				67	1.5	2.0	44	1.6	2.7	30	1.8	3.4	24	1.9	3.9	19	2.0	4.4	15	2.2	5.0	12	2.4	5.4	11	2.6	5.6
80				72	1.5	2.0	47	1.6	2.7	32	1.8	3.4	26	1.9	3.9	21	2.0	4.4	16	2.2	5.0	13	2.4	5.4	12	2.5	5.8
90				80	1.5	2.0	53	1.6	2.7	36	1.8	3.5	29	1.9	3.9	23	2.0	4.4	18	2.2	5.0	15	2.4	5.4	13	2.5	5.9
100				89	1.5	2.0	59	1.6	2.7	39	1.8	3.5	32	1.9	3.9	26	2.0	4.5	20	2.2	5.0	17	2.4	5.4	14	2.5	6.0
110				98	1.5	2.0	64	1.6	2.7	43	1.8	3.5	35	1.9	3.9	28	2.0	4.5	22	2.2	5.0	18	2.3	5.5	15	2.5	6.0
120							70	1.6	2.7	47	1.8	3.5	38	1.9	4.0	31	2.0	4.5	24	2.2	5.0	20	2.3	5.5	17	2.5	6.0
130							76	1.6	2.7	51	1.8	3.5	41	1.9	4.0	33	2.0	4.5	26	2.2	5.0	21	2.3	5.5	18	2.5	6.0
140							82	1.6	2.7	55	1.8	3.5	44	1.9	4.0	36	2.0	4.5	27	2.2	5.0	23	2.3	5.5	19	2.5	6.0
150							87	1.6	2.7	59	1.8	3.5	47	1.9	4.0	39	2.0	4.5	29	2.2	5.0	25	2.3	5.5	21	2.5	6.0
160							93	1.6	2.7	63	1.8	3.5	51	1.9	4.0	41	2.0	4.5	31	2.2	5.0	26	2.3	5.5	22	2.5	6.0
170							99	1.6	2.7	67	1.8	3.5	54	1.9	4.0	44	2.0	4.5	33	2.2	5.0	28	2.3	5.5	23	2.5	6.0
180										70	1.8	3.5	57	1.9	4.0	46	2.0	4.5	35	2.2	5.0	29	2.3	5.5	25	2.5	6.0
190										74	1.8	3.5	60	1.9	4.0	49	2.0	4.5	37	2.2	5.0	31	2.3	5.5	26	2.5	6.0
200										78	1.8	3.5	63	1.9	4.0	51	2.0	4.5	39	2.2	5.0	33	2.3	5.5	27	2.5	6.0
220										86	1.8	3.5	69	1.9	4.0	56	2.0	4.5	43	2.2	5.0	36	2.3	5.5	30	2.5	6.0
240										93	1.8	3.5	75	1.9	4.0	61	2.0	4.5	47	2.2	5.0	39	2.3	5.5	33	2.5	6.0
260													82	1.9	4.0	66	2.0	4.5	51	2.2	5.0	42	2.3	5.5	35	2.5	6.0
280													88	1.9	4.0	71	2.0	4.5	54	2.2	5.0	46	2.3	5.5	38	2.5	6.0
300													94	1.9	4.0	76	2.0	4.5	58	2.2	5.0	49	2.3	5.5	41	2.5	6.0

T = Top width, Retardance "C"
D = Depth, Retardance "C"
V_2 = Velocity, Retardance "C"
V_1 = Velocity, Retardance "D"
(Settlement to be added to top of ridge.)

Parabolic diversion design chart (Sheet 11 of 13)

V_1 Based on Permissible Velocity of the Soil With Retardance "D"

Top Width, Depth & V_2 Based on Retardance "C" Grade = 2.0%

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	27	1.3	1.3	16	1.4	1.9	11	1.5	2.4																		
20	35	1.3	1.3	21	1.4	1.9	15	1.5	2.4	11	1.6	3.0															
25	44	1.3	1.3	27	1.4	1.9	19	1.5	2.4	13	1.6	3.0	10	1.8	3.7												
30	53	1.3	1.3	32	1.4	1.9	23	1.5	2.5	16	1.6	3.0	11	1.7	3.7	10	1.8	4.2									
35	61	1.3	1.3	37	1.4	1.9	26	1.5	2.5	19	1.6	3.1	13	1.7	3.8	11	1.8	4.2									
40	70	1.3	1.3	42	1.4	1.9	30	1.5	2.5	21	1.6	3.1	15	1.7	3.8	12	1.8	4.3	10	2.0	4.7						
45	78	1.3	1.4	48	1.4	1.9	34	1.5	2.5	24	1.6	3.1	17	1.7	3.8	14	1.8	4.3	11	1.9	4.8						
50	87	1.3	1.4	53	1.4	1.9	38	1.5	2.5	26	1.6	3.1	19	1.7	3.8	15	1.8	4.3	13	1.9	4.8	10	2.1	5.3			
55	95	1.3	1.4	58	1.4	1.9	41	1.5	2.5	29	1.6	3.1	21	1.7	3.8	17	1.8	4.3	14	1.9	4.9	11	2.1	5.3			
60				63	1.4	1.9	45	1.5	2.5	32	1.6	3.1	23	1.7	3.9	18	1.8	4.4	15	1.9	4.9	12	2.1	5.3	10	2.2	5.7
65				68	1.4	1.9	49	1.5	2.5	34	1.6	3.1	24	1.7	3.9	20	1.8	4.4	16	1.9	4.9	13	2.1	5.4	11	2.2	5.7
70				73	1.4	1.9	52	1.5	2.5	37	1.6	3.1	26	1.7	3.9	22	1.8	4.4	18	1.9	4.9	14	2.1	5.4	12	2.2	5.8
75				78	1.4	1.9	56	1.5	2.5	39	1.6	3.1	28	1.7	3.9	23	1.8	4.4	19	1.9	4.9	15	2.1	5.4	13	2.2	5.9
80				83	1.4	2.0	60	1.5	2.5	42	1.6	3.1	30	1.7	3.9	24	1.8	4.4	20	1.9	4.9	16	2.1	5.4	14	2.2	5.9
90				94	1.4	2.0	67	1.5	2.5	47	1.6	3.2	34	1.7	3.9	28	1.8	4.4	22	1.9	4.9	18	2.1	5.5	15	2.2	5.9
100							74	1.5	2.5	52	1.6	3.2	37	1.7	3.9	31	1.8	4.4	25	1.9	5.0	20	2.1	5.5	17	2.2	6.0
110							81	1.5	2.5	57	1.6	3.2	41	1.7	3.9	34	1.8	4.4	27	1.9	5.0	22	2.0	5.5	19	2.2	6.0
120							89	1.5	2.5	62	1.6	3.2	45	1.7	3.9	37	1.8	4.4	30	1.9	5.0	24	2.0	5.5	20	2.2	6.0
130							96	1.5	2.5	67	1.6	3.2	48	1.7	3.9	40	1.8	4.5	32	1.9	5.0	26	2.0	5.5	22	2.2	6.0
140										73	1.6	3.2	52	1.7	4.0	42	1.8	4.5	35	1.9	5.0	28	2.0	5.5	23	2.2	6.0
150										78	1.6	3.2	56	1.7	4.0	46	1.8	4.5	37	1.9	5.0	30	2.0	5.5	25	2.2	6.0
160										83	1.6	3.2	59	1.7	4.0	48	1.8	4.5	39	1.9	5.0	32	2.0	5.5	27	2.2	6.0
170										88	1.6	3.2	63	1.7	4.0	51	1.8	4.5	42	1.9	5.0	34	2.0	5.5	28	2.2	6.0
180										93	1.6	3.2	67	1.7	4.0	54	1.8	4.5	44	1.9	5.0	36	2.0	5.5	30	2.2	6.0
190										98	1.6	3.2	70	1.7	4.0	57	1.8	4.5	47	1.9	5.0	38	2.0	5.5	32	2.2	6.0
200													74	1.7	4.0	60	1.8	4.5	49	1.9	5.0	40	2.0	5.5	33	2.2	6.0
220													81	1.7	4.0	66	1.8	4.5	54	1.9	5.0	44	2.0	5.5	37	2.2	6.0
240													88	1.7	4.0	72	1.8	4.5	59	1.9	5.0	48	2.0	5.5	40	2.2	6.0
260													96	1.7	4.0	78	1.8	4.5	64	1.9	5.0	51	2.0	5.5	43	2.2	6.0
280																84	1.8	4.5	69	1.9	5.0	55	2.0	5.5	46	2.2	6.0
300																90	1.8	4.5	73	1.9	5.0	59	2.0	5.5	50	2.2	6.0

T = Top width, Retardance "C"
D = Depth, Retardance "C"
V_2 = Velocity, Retardance "C"
V_1 = Velocity, Retardance "D"

(Settlement to be added to top of ridge.)

Parabolic diversion design chart (Sheet 12 of 13)

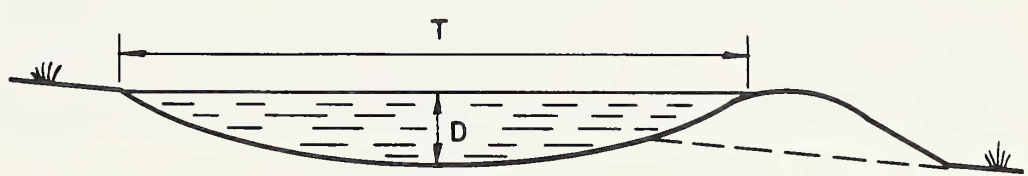
PARABOLIC DIVERSION DESIGN, WITHOUT FREEBOARD

RETARDANCE - D
GRADE, % - 0.25 to 2.0

Velocity, Depth and Top Width Based on Retardance "D"

	Grade 0.25%			Grade 0.50%			Grade 0.75%			Grade 1.0%			Grade 1.25%			Grade 1.50%			Grade 2.0%		
V	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0
D	1.2	1.7	2.1	0.9	1.1	1.4	0.7	0.9	1.1	0.7	0.8	0.9	0.6	0.7	0.8	0.5	0.7	0.8	0.5	0.6	0.7
Q	Top Widths																				
5				8			10	5		11	6		13	7		14	7	5	15	9	5
10	11			17	9		20	10	7	23	12	8	25	14	8	27	15	10	31	17	11
15	18	9		25	13	8	30	16	10	34	19	12	38	21	13	41	23	15	46	26	16
20	24	12		34	18	10	40	22	14	46	25	16	50	28	18	54	30	20	61	34	22
25	30	15		42	23	13	50	27	17	57	31	20	63	35	22	68	38	24		43	27
30	36	18	10	51	27	16	60	33	20	69	37	24		42	27		45	29		52	33
35	43	21	12	59	32	18	71	38	24		44	28		49	31		53	34		60	38
40	49	24	14	68	36	21	81	44	27		50	32		56	35		61	39		69	44
45	55	27	15	76	41	24	91	49	31		56	36		63	40		68	44			49
50	61	30	17	85	45	26	101	54	34		62	40		70	44			49			55
55	67	33	19	93	50	29	111	60	37		68	43			49			54			60
60	73	36	20	101	54	32		65	41		75	47			53			59			66
65	79	39	22	110	59	34		71	44			51			58			64			71
70	85	42	24		63	37		76	48			55			62			68			
75	91	45	26		68	39		82	51			59			67			73			
80	97	48	27		72	42		87	54			63			71						
90		55	31		81	47		98	61			71									
100		61	34		90	53		109	68												
110		67	38		99	58			75												
120		73	41		108	63			82												
130		79	44			68			89												
140		85	48			74			95												
150		91	51			79															
160		97	55			84															
170			58			89															
180			62			95															
190			65																		
200			68																		

Top widths (T) and depths (D) shown are for the hydraulic section. Freeboard and allowance for settlement are to be added as necessary.



PARABOLIC DIVERSION CHART

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

● 3:1 Side Slopes
"D" Retardance

(Based on Handbook of Channel Design, SCS-TP-61)

Triangular

Grade	0.2 d	0.2 A	0.3 d	0.3 A	0.4 d	0.4 A	0.5 d	0.5 A
Q-cfs	d	A	d	A	d	A	d	A
10	1.9	11	1.8	10	1.7	9	1.6	8
20	2.2	15	2.1	13	1.9	11	1.8	10
30	2.5	19	2.3	16	2.2	15	2.0	12
40	2.6	20	2.5	19	2.3	16	2.2	15
60	3.0	27	2.8	24	2.7	22	2.5	19
80			3.1	29	2.9	25	2.7	22
100					3.1	29	2.9	25
120							3.0	27
140								
160								
180								
200								
220								

6' bottom width

Grade	0.2 d	0.2 A	0.3 d	0.3 A	0.4 d	0.4 A	0.5 d	0.5 A
Q-cfs	d	A	d	A	d	A	d	A
10	1.3	12	1.1	10	1.0	9	0.9	8
20	1.5	16	1.4	14	1.2	12	1.1	10
30	1.8	21	1.6	17	1.5	16	1.3	13
40	2.0	24	1.8	21	1.7	19	1.5	16
60	2.3	30	2.1	26	1.9	22	1.7	19
80	2.5	34	2.3	30	2.1	26	1.9	22
100	2.8	40	2.5	34	2.3	30	2.1	26
120	3.0	45	2.8	40	2.5	34	2.3	30
140			2.9	43	2.6	36	2.4	32
160			3.0	45	2.8	40	2.6	36
180								
200								
220								

8' bottom width

Grade	0.2 d	0.2 A	0.3 d	0.3 A	0.4 d	0.4 A	0.5 d	0.5 A
Q-cfs	d	A	d	A	d	A	d	A
10	1.2	13	1.1	11	1.0	10	0.9	9
20	1.4	17	1.3	16	1.2	14	1.1	12
30	1.7	22	1.5	19	1.4	17	1.2	14
40	1.8	24	1.7	22	1.5	19	1.4	17
60	2.1	30	1.9	26	1.8	24	1.6	21
80	2.4	37	2.2	32	2.0	28	1.8	24
100	2.6	41	2.4	37	2.2	32	2.0	28
120	2.8	46	2.5	39	2.3	34	2.1	30
140	2.9	48	2.7	44	2.5	39	2.3	34
160	3.1	51	2.9	48	2.7	44	2.5	39
180							2.6	41
200								
220								

10' bottom width

Grade	0.2 d	0.2 A	0.3 d	0.3 A	0.4 d	0.4 A	0.5 d	0.5 A
Q-cfs	d	A	d	A	d	A	d	A
10	1.1	14	1.0	12	0.9	11	0.8	10
20	1.3	18	1.2	16	1.0	13	0.9	11
30	1.5	22	1.4	20	1.2	16	1.1	15
40	1.7	26	1.5	22	1.4	20	1.2	16
60	2.0	32	1.8	28	1.7	26	1.5	22
80	2.3	39	2.1	34	1.9	30	1.7	26
100	2.4	41	2.2	37	2.1	34	1.9	30
120	2.6	46	2.4	41	2.2	37	2.0	32
140	2.7	49	2.5	44	2.3	39	2.1	34
160	2.9	54	2.7	49	2.5	44	2.3	39
180	3.0	57	2.8	51	2.6	46	2.4	41
200							2.5	44
220								

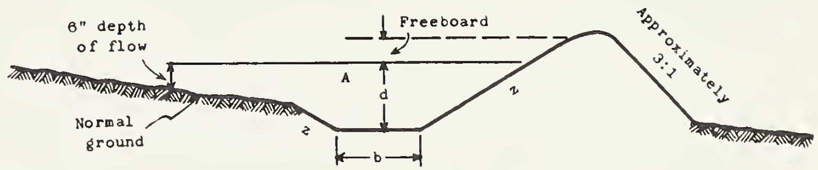
12' bottom width

Grade	0.2 d	0.2 A	0.3 d	0.3 A	0.4 d	0.4 A	0.5 d	0.5 A
Q-cfs	d	A	d	A	d	A	d	A
10	1.0	14	0.9	12	0.8	11	0.7	10
20	1.2	19	1.1	17	1.0	15	0.9	13
30	1.3	21	1.2	19	1.2	19	1.1	17
40	1.6	27	1.5	25	1.3	21	1.2	19
60	1.8	31	1.6	27	1.5	25	1.3	21
80	2.1	38	1.9	34	1.8	31	1.6	27
100	2.3	44	2.1	38	1.9	34	1.7	29
120	2.5	50	2.3	44	2.1	38	1.9	34
140	2.6	52	2.4	46	2.2	41	2.0	36
160	2.7	54	2.5	50	2.3	44	2.1	38
180	2.8	57	2.6	52	2.4	46	2.2	41
200	2.9	60	2.7	54	2.5	50	2.3	44
220	3.0	63	2.8	57	2.7	54	2.5	50

NOTE: For diversions built on slopes under 2% the available cross-sectional area above normal ground will allow a reduction in design depth as follows:

For land slopes of 1% or less reduce depth of flow (taken from Design Table) 20%.
For land slopes of 1% to 2% reduce depth of flow (taken from Design Table) 10%.
For land slopes greater than 2% use depth of flow taken from Design Table.

For Example: A diversion 6 feet wide with a 2.5 foot depth of flow is required to remove 120 c.f.s. on a 0.4% grade. If this is built on a 1% slope the depth may be reduced 20% thus obtaining a flow depth of 2.0 feet. The required cross-sectional area of the channel plus that above normal ground line will be 34 square feet corresponding to the 2.5 foot depth. The overall height of diversion will be 2.0 feet plus 0.5 foot freeboard or 2.5 feet, instead of the original 3.0 feet.



d = depth of flow, feet
b = bottom width of channel, feet
A = channel capacity, sq. ft., including area below 0.5' freeboard and excluding any area less than 0.5' depth of flow
z = side slope of channel (horizontal to vertical)

IMPORTANT: To all designed depths of flow add freeboard required by State Standards and Specifications to obtain overall height of terrace above bottom of channel. For final check on cross-sectional area subtract required freeboard from settled height of diversion and provide for cross-sectional area shown in table.

Diversion design table - "D" Retardance (V and Trapezoidal Section)
(Sheet 1 of 4)

3/27/53 4-L-8618-1

(Based on Handbook of Channel Design, SCS-TP-61)

● 4:1 Side Slopes
"D" Retardance

	Triangular								6' bottom width							
Grade	0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5	
Q-cfs	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A
10	1.8	13	1.7	12	1.6	11	1.5	10	1.2	13	1.1	11	1.0	10	0.9	9
20	2.1	18	2.0	16	1.8	13	1.7	12	1.5	18	1.4	16	1.2	13	1.1	11
30	2.4	23	2.2	19	2.1	18	1.9	14	1.9	24	1.6	20	1.5	19	1.3	15
40	2.5	25	2.4	23	2.2	19	2.1	18	1.9	28	1.8	24	1.6	20	1.5	18
60	2.8	31	2.6	27	2.5	25	2.3	21	2.2	33	2.0	28	1.9	26	1.7	22
80	3.1	38	2.9	34	2.7	29	2.5	25	2.4	37	2.2	33	2.1	30	1.9	28
100			3.1	38	2.9	34	2.7	29	2.7	45	2.5	40	2.3	35	2.1	30
120							2.9	31	2.9	51	2.7	45	2.4	37	2.2	33
140									3.0	54	2.9	48	2.6	43	2.4	37
160									3.1	57	2.9	51	2.8	48	2.6	43
180																
200																
220																

	8' bottom width								10' bottom width								12' bottom width							
Grade	0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5	
Q-cfs	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A
10	1.1	14	1.0	13	0.9	11	0.8	10	1.1	14	1.0	13	0.9	12	0.9	11	1.0	15	0.9	14	0.8	13	0.7	12
20	1.4	19	1.3	17	1.2	15	1.1	14	1.3	20	1.2	18	1.0	14	0.9	12	1.2	20	1.1	18	1.0	16	0.9	14
30	1.7	25	1.5	21	1.4	19	1.2	15	1.5	24	1.4	22	1.2	18	1.1	16	1.3	22	1.2	20	1.2	20	1.1	18
40	1.8	27	1.7	25	1.5	21	1.4	19	1.6	26	1.5	24	1.3	20	1.2	18	1.6	29	1.5	27	1.3	22	1.2	20
60	2.0	32	1.9	30	1.7	25	1.6	23	1.9	33	1.8	31	1.6	28	1.5	24	1.7	32	1.6	29	1.4	25	1.3	22
80	2.3	40	2.1	34	2.0	32	1.9	27	2.2	41	2.0	36	1.8	31	1.6	26	2.0	40	1.9	37	1.7	32	1.6	29
100	2.5	45	2.3	40	2.1	34	1.9	30	2.3	44	2.1	39	2.0	36	1.8	31	2.2	46	2.0	40	1.9	37	1.7	32
120	2.7	51	2.5	45	2.3	40	2.1	34	2.5	50	2.3	44	2.2	41	2.0	36	2.4	52	2.2	46	2.0	40	1.8	35
140	2.8	54	2.6	48	2.5	45	2.3	40	2.6	53	2.4	47	2.3	44	2.1	39	2.5	55	2.3	49	2.2	46	2.0	40
160	3.0	60	2.8	54	2.6	48	2.4	42	2.8	59	2.6	53	2.5	50	2.3	44	2.7	62	2.5	55	2.3	49	2.1	43
180							2.5	45	2.9	63	2.7	56	2.6	53	2.4	47	2.8	65	2.6	58	2.4	52	2.2	46
200															2.5	50	2.9	68	2.7	62	2.5	55	2.3	49
220																	3.0	72	2.8	65	2.6	58	2.4	52

● 6:1 Side Slopes
"D" Retardance

	Triangular								6' bottom width							
Grade	0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5	
Q-cfs	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A
10	1.6	15	1.5	14	1.4	13	1.3	11	1.2	16	1.1	14	1.0	12	0.9	10
20	1.9	22	1.8	19	1.6	15	1.5	14	1.5	23	1.4	20	1.2	16	1.1	14
30	2.1	27	2.0	24	1.8	19	1.7	17	1.7	28	1.5	23	1.4	20	1.2	16
40	2.3	32	2.2	29	2.0	24	1.9	19	1.8	30	1.7	28	1.5	23	1.4	20
60	2.5	38	2.3	32	2.2	26	2.0	24	2.0	36	1.9	33	1.7	28	1.6	25
80	2.7	44	2.5	38	2.4	35	2.2	29	2.2	42	2.1	39	1.9	33	1.8	30
100	2.9	51	2.7	44	2.6	41	2.4	35	2.4	49	2.2	42	2.1	39	1.9	33
120	3.0	54	2.8	47	2.7	44	2.5	38	2.6	56	2.4	49	2.3	46	2.1	39
140									2.7	61	2.6	56	2.4	49	2.3	46
160									2.9	68	2.8	64	2.6	56	2.5	53
180																
200																
220																
240																
260																

	8' bottom width								10' bottom width								12' bottom width							
Grade	0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5	
Q-cfs	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A
10	1.1	16	1.0	14	0.9	13	0.8	11	1.1	17	1.0	15	0.9	13	0.8	12	1.0	17	0.9	15	0.8	14	0.7	12
20	1.4	23	1.3	21	1.1	16	1.0	14	1.3	21	1.2	20	1.1	18	1.0	16	1.3	25	1.2	23	1.0	17	0.9	16
30	1.6	28	1.5	26	1.3	21	1.2	18	1.4	26	1.3	23	1.2	20	1.1	18	1.4	29	1.3	27	1.1	20	1.0	18
40	1.7	31	1.6	28	1.4	23	1.3	21	1.5	29	1.4	26	1.3	23	1.2	20	1.5	32	1.4	29	1.3	27	1.2	22
60	1.9	37	1.8	34	1.6	28	1.5	26	1.8	38	1.7	34	1.5	29	1.4	26	1.6	34	1.5	32	1.4	29	1.3	27
80	2.1	43	2.0	40	1.8	34	1.7	31	2.0	44	1.9	41	1.7	34	1.6	31	1.8	41	1.7	37	1.6	34	1.5	32
100	2.3	50	2.1	43	2.0	40	1.8	34	2.2	51	2.0	44	1.9	41	1.7	34	2.1	51	1.9	45	1.8	41	1.6	34
120	2.5	58	2.3	50	2.2	47	2.0	40	2.3	55	2.2	51	2.0	44	1.9	41	2.2	55	2.0	48	1.9	45	1.7	37
140	2.6	61	2.5	58	2.3	50	2.2	47	2.5	63	2.3	55	2.2	51	2.0	44	2.4	64	2.2	55	2.1	51	1.9	45
160	2.8	67	2.6	61	2.5	58	2.3	50	2.7	71	2.5	63	2.4	59	2.2	51	2.6	70	2.4	64	2.3	59	2.1	51
180	2.9	71	2.7	64	2.6	61	2.4	54	2.8	75	2.6	67	2.5	63	2.3	55	2.7	76	2.5	68	2.4	63	2.2	55
200	3.0	72	2.8	67	2.6	61	2.4	54	2.9	79	2.7	77	2.6	67	2.4	59	2.8	81	2.6	72	2.5	68	2.3	59
220							2.5	59							2.4	59	2.9	85	2.7	76	2.5	68	2.3	59
240															2.5	63							2.4	64
260																							2.5	68

4-L-8618-2

Diversion design table - "D" Retardance (V and Trapezoidal Section) (Sheet 2 of 4)

(Based on Handbook of Channel Design, SCS-TP-61)

● 3:1 Side Slopes
"C" Retardance

	Triangular								6' bottom								8' bottom								10' bottom								12' bottom							
Grade	0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5	
Q	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A
20	2.5	19	2.3	16	2.1	13	1.9	11	1.9	22	1.7	19	1.5	16	1.4	14	1.7	22	1.5	19	1.4	17	1.3	15	1.6	24	1.4	20	1.3	18	1.2	16								
30			2.5	19	2.3	16	2.2	15	2.0	24	1.8	21	1.7	19	1.5	16	1.9	26	1.7	22	1.5	19	1.4	17	1.7	26	1.5	22	1.4	20	1.3	18	1.6	27	1.4	23	1.3	21	1.2	19
40					2.5	19	2.4	17	2.2	28	2.0	24	1.9	22	1.7	19	2.0	28	1.8	24	1.6	21	1.5	19	1.9	30	1.7	26	1.5	22	1.4	20	1.8	31	1.6	27	1.5	25	1.4	23
50							2.5	19	2.3	30	2.1	26	2.0	24	1.8	21	2.2	32	2.0	28	1.8	24	1.6	21	2.0	32	1.8	28	1.6	24	1.5	22	1.9	34	1.7	29	1.6	27	1.5	25
60									2.5	34	2.3	30	2.1	26	1.9	22	2.3	34	2.1	30	1.9	26	1.8	24	2.2	37	2.0	32	1.8	28	1.6	24	2.0	36	1.8	31	1.7	29	1.6	27
80											2.5	34	2.3	30	2.1	26	2.5	39	2.3	34	2.1	30	1.9	26	2.4	41	2.2	37	2.0	32	1.8	28	2.2	41	2.0	36	1.9	34	1.7	29
100													2.5	34	2.3	30			2.5	39	2.3	34	2.1	30			2.4	41	2.2	37	2.0	32	2.5	49	2.2	41	2.0	36	1.8	31
120															2.5	34					2.5	39	2.3	34					2.3	39	2.1	34			2.4	46	2.2	41	2.0	36
140																							2.4	36					2.5	44	2.3	39					2.3	43	2.1	38
160																															2.4	41					2.4	46	2.2	41
180																															2.5	44							2.4	46
200																																							2.5	49
220																																							2.6	51

● 4:1 Side Slopes
"C" Retardance

	Triangular								6' bottom width								8' bottom width								10' bottom width								12' bottom width							
Grade	0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5	
Q	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A
30	2.5	25	2.4	23	2.3	21	2.1	18	2.0	28	1.8	24	1.6	20	1.5	18	1.8	27	1.7	25	1.5	21	1.4	19	1.8	31	1.6	26	1.4	22	1.3	20	1.7	32	1.6	29	1.4	25	1.2	20
40			2.5	25	2.4	23	2.2	19	2.1	30	1.9	26	1.7	22	1.6	20	2.0	32	1.8	27	1.6	23	1.5	21	1.9	33	1.7	29	1.5	24	1.4	22	1.8	35	1.7	32	1.5	27	1.3	22
50					2.5	25	2.4	23	2.3	35	2.1	30	1.9	26	1.7	22	2.1	34	1.9	30	1.7	25	1.6	23	2.0	36	1.8	31	1.6	26	1.5	24	1.9	37	1.8	35	1.6	29	1.4	25
60							2.5	25	2.4	37	2.2	33	2.0	28	1.9	26	2.3	40	2.1	34	1.9	30	1.7	25	2.1	39	1.9	34	1.7	29	1.6	26	2.0	40	1.9	37	1.7	32	1.5	27
80											2.4	37	2.2	33	2.0	28	2.5	45	2.3	40	2.1	34	1.9	30	2.3	44	2.1	39	1.9	34	1.8	31	2.2	46	2.0	40	1.8	35	1.7	32
100											2.5	40	2.3	35	2.2	33			2.5	45	2.3	40	2.0	32	2.5	50	2.3	44	2.1	39	1.9	34	2.3	49	2.1	43	2.0	40	1.8	35
120													2.5	40	2.4	37					2.4	42	2.2	37			2.5	50	2.3	44	2.1	39	2.5	55	2.3	49	2.2	46	2.0	40
140															2.5	40					2.5	45	2.3	40					2.4	47	2.2	41			2.5	55	2.3	49	2.1	43
160																							2.5	45					2.5	50	2.3	44					2.4	52	2.2	46
180																															2.4	47					2.5	55	2.3	49
200																															2.5	50							2.4	52
220																																							2.5	55

Diversion design table - "C" Retardance (V and Trapezoidal Section)
(Sheet 3 of 4)

10-26-55 4-L-10122-1

● 6:1 Side Slopes
"C" Retardance

(Based on Handbook of Channel Design, SCS-TP-61)

Grade	Triangular								6' bottom width							
	0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5	
Q	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A
20	2.2	29	2.1	26	1.9	22	1.8	19	1.8	30	1.7	28	1.6	25	1.4	20
30	2.4	35	2.2	29	2.1	26	1.9	22	2.0	36	1.9	33	1.7	28	1.5	23
4C	2.5	38	2.3	32	2.2	29	2.0	24	2.1	39	2.0	36	1.8	30	1.6	25
50			2.5	38	2.3	32	2.1	26	2.2	42	2.1	39	1.9	33	1.7	28
60					2.4	35	2.2	29	2.3	46	2.2	42	2.0	36	1.8	30
80					2.5	38	2.3	32	2.5	53	2.3	46	2.1	39	1.9	33
100							2.5	38			2.5	53	2.3	46	2.1	39
120													2.4	49	2.2	42
140													2.5	53	2.3	46
160															2.4	49
180															2.5	53
200																
220																

Grade	8' bottom width								10' bottom width							
	0.2		0.3		0.4		0.5		0.2		0.3		0.4		0.5	
Q	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A
20	1.7	31	1.6	28	1.5	26	1.3	21	1.6	31	1.5	29	1.4	26	1.2	20
30	1.8	34	1.7	31	1.6	28	1.4	23	1.8	38	1.7	34	1.5	29	1.3	23
4C	2.0	40	1.9	37	1.7	31	1.5	26	1.9	41	1.8	38	1.6	31	1.4	26
50	2.1	43	2.0	40	1.8	34	1.6	28	2.0	44	1.9	41	1.7	34	1.5	29
60	2.2	47	2.1	43	1.9	37	1.7	31	2.1	47	2.0	44	1.8	38	1.6	31
80	2.4	54	2.2	47	2.0	40	1.8	34	2.3	55	2.1	47	1.9	41	1.7	34
100	2.5	58	2.4	54	2.2	47	2.0	40	2.4	59	2.3	55	2.1	47	1.9	41
120			2.5	58	2.3	50	2.1	43	2.5	63	2.4	59	2.2	51	2.0	44
140					2.4	54	2.2	47			2.5	63	2.3	55	2.1	47
160					2.5	58	2.3	50					2.4	59	2.2	51
180							2.4	54					2.5	63	2.3	55
200							2.5	58							2.4	59
220															2.5	63

Grade	12' bottom width							
	0.2		0.3		0.4		0.5	
Q	d	A	d	A	d	A	d	A
20	1.5	32	1.4	29	1.3	27	1.2	22
30	1.7	37	1.6	34	1.4	29	1.3	27
4C	1.8	41	1.7	37	1.5	32	1.3	27
50	1.9	45	1.8	41	1.6	34	1.4	29
60	2.0	48	1.9	45	1.8	41	1.6	34
80	2.2	55	2.1	52	1.9	45	1.7	37
100	2.3	59	2.2	55	2.0	48	1.8	41
120	2.4	64	2.3	59	2.1	52	1.9	45
140	2.5	68	2.4	64	2.2	55	2.0	48
160			2.5	68	2.3	59	2.1	52
180					2.4	64	2.2	55
200					2.5	68	2.2	55
220							2.3	59

4-L-10122-2

Diversion design table - "C" Retardance.(V and Trapezoidal Section)(Sheet 4 of 4)

WATERWAY DESIGN AIDS

The following example demonstrates how to use the exhibit to design a parabolic channel.

Problem: Determine the safe velocity and dimensions for stability and capacity for a waterway with parabolic cross section.

Given:

Runoff	Q =	55 c.f.s.
Grade	=	5 percent
Vegetative Cover		Kentucky Bluegrass
Soil		Easily eroded
Condition of Vegetation		
Good stand--Mowed (3" - 4")	=	"D" curve retardance (from Page B-3.2)
Good stand--Headed (6" - 12")	=	"C" curve retardance (from Page B-3.2)
Permissible Velocity V_1	=	4.0 f.p.s. (from Page B-3.3)

Horizontally opposite 55 c.f.s. in B-3.31 (5 percent slope) in the columns headed V_1 = 4.0 f.p.s., find T = 32.6 feet, D = 0.75 foot and V_2 = 3.33 f.p.s. Therefore a waterway with parabolic cross section, a top width of 32.6 feet, and a depth of 0.75 foot will carry 55 c.f.s. at a maximum velocity of 4 feet per second when the vegetative lining is short (3" to 4" in height) and 3.33 feet per second when vegetative lining is tall (6" to 12"). This complies with the requirements for safe velocity when vegetation is short ("D" retardance) and capacity when vegetation is tall ("C" retardance).

WATERWAY DESIGN

Retardance	Cover	Stand	Condition and Height
A	Reed canarygrass Tall fescue Smooth bromegrass	Excellent Excellent Excellent	Tall (Average 36") Tall (Average 36") Tall (Average 36")
B	Tall fescue Smooth bromegrass Red fescue Kentucky bluegrass Redtop	Good Good Good Good Good	Average (20" tall) Average (20" tall) Uncut (Average 16" tall) Uncut (Average 16" tall) Average (22" tall)
C	Kentucky bluegrass Red fescue	Good Good	Headed (6 to 12") Headed (6 to 12")
D	Red fescue	Good	Cut to 2.5"

Classification of vegetal cover in waterways and channels as to degree of retardance.

USDA, Soil Conservation Service
Columbus, Ohio

WATERWAY DESIGN

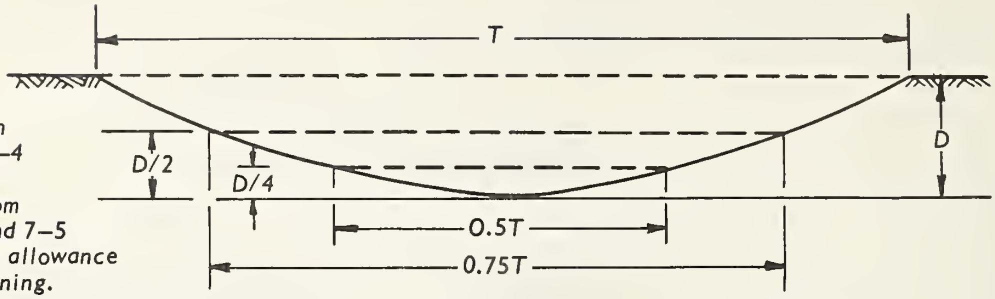
Cover	Slope range 2/ (percent)	Permissible Velocity 1/	
		Erosion resistant soils (ft. per sec.	Easily eroded soils (ft. per sec.)
Kentucky bluegrass Tall fescue	0-5 5-10 over 10	7 6 5	5 4 3
Grass mixtures	2/ 0-5 5-10	5 4	4 3
Redtop Red fescue	3/ 0-5	3.5	2.5

1/ Use velocities exceeding 5 feet per second only where good cover and proper maintenance can be obtained.

2/ Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

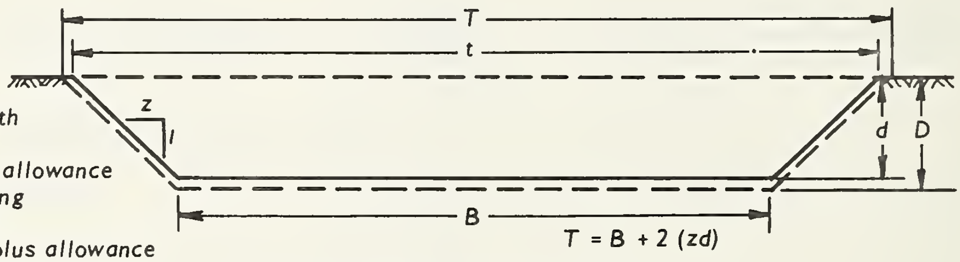
3/ Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

T = design top width from Exhibits 7–4 and 7–5
D = design depth from Exhibits 7–4 and 7–5
Both values include allowance for the vegetative lining.



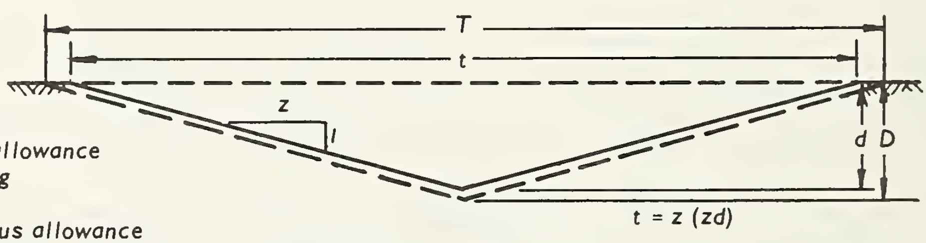
PARABOLIC CROSS SECTION

B = design bottom width
d = design depth
D = design depth plus allowance for vegetative lining
t = design top width
T = design top width plus allowance for vegetative lining
z = side slope ratio



TRAPEZOIDAL CROSS SECTION

d = design depth
D = design depth plus allowance for vegetative lining
t = design top width
T = design top width plus allowance for vegetative lining
z = side slope ratio



TRIANGULAR CROSS SECTION

TYPICAL WATERWAY CROSS SECTIONS

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE   4–68 4–L–26356

PARABOLIC WATERWAY DESIGN, WITHOUT FREEBOARD

RETARDANCE - D & B
GRADE, % - 0.25 to 2.0

	Grade, 0.25%			Grade, 0.50%			Grade, 0.75%			Grade, 1.0%			Grade, 1.25%			Grade, 1.50%			Grade, 2.0%		
V	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5
D	1.5	2.1	2.5	1.0	1.6	1.8	0.8	1.4	1.6	0.7	1.2	1.4	0.7	1.1	1.3	0.6	1.0	1.2	0.5	0.8	1.1
Q										Top Width											
5	22			27	11		32	14	7	34	15	8	36	17	9	39	19	10	43	20	12
10	43	15		55	23	12	63	27	14	68	31	17	73	34	19	77	36	20	85	40	23
15	65	24	12	82	34	18	95	41	22	102	46	25	109	50	28	115	54	31	128	60	35
20	87	32	16	110	46	24		54	29		61	33		67	37		71	41		79	47
25	108	41	21		57	30		68	36		77	41		84	47		89	51		99	58
30		49	25		69	36		82	43		92	50		101	56		107	61			70
35		57	29		80	41		95	50		107	58			66			72			82
40		65	33		92	47		109	57			66			75			82			93
45		73	37		103	53			64			75			84			92			105
50		81	42			59			72			83			94			102			
55		90	46			65			79			91			103						
60		98	50			71			86			100									
65		106	58			77			93												
70			63			83			100												
75			67			89															
80			75			95															
90			83			107															
100			92																		
110			100																		

V, permissible velocity of soil with vegetative retardance "D"
Depth and top width are for cross section with retardance "B"

Q, in cfs
V, in fps
D, depth in ft.
Top Width, in ft.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
UNIT

PARABOLIC WATERWAY DESIGN, WITHOUT FREEBOARD

RETARDANCE - D & C
GRADE, % - 0.25 to 2.0

	Grade, 0.25%			Grade, 0.50%			Grade, 0.75%			Grade, 1.0%			Grade, 1.25%			Grade, 1.50%			Grade, 2.0%		
V	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5
D	1.3	1.5	1.8	1.0	1.1	1.3	0.8	1.0	1.1	0.7	0.9	1.0	0.6	0.8	0.9	0.6	0.8	0.8	0.5	0.7	0.8
Q	Top Width																				
5	20			26	9		30	12	6	33	13	7	35	15	8	37	16	8	41	18	10
10	40	13		53	19	10	61	23	12	65	27	14	70	30	16	74	32	17	82	36	20
15	60	20	10	79	29	15	91	35	18	98	40	21	105	44	24	111	48	26	123	54	29
20	81	27	14	106	39	20	121	47	24		53	28		59	32		63	34		72	39
25	101	34	17		48	25		58	30		66	35		74	39		79	43		90	49
30		41	21		58	30		70	36		80	42		89	47		95	52		108	59
35		48	25		68	35		82	42		93	49		103	55		111	60			69
40		55	28		77	40		93	49		106	56			63			69			79
45		62	32		87	45		105	55			63			71			77			88
50		69	35		97	50			61			70			79			86			98
55		75	39		106	55			67			77			87			95			108
60		82	43			60			73			84			95			103			
65		89	46			65			79			91			102						
70		96	50			71			85			98									
75		103	53			76			91			105									
80			57			81			97												
90			64			91			109												
100			71			101															
110			78																		
120			85																		
130			93																		
140			100																		

V, permissible velocity of soil with vegetative retardance "D"
Depth and top width are for cross section with retardance "C"

Q, in cfs
V, in fps
D, depth in ft.
Top Width, in ft.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 0.25 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15																											
20																											
25	11.3	3.27	1.00																								
30	13.2	3.09	1.09																								
35	15.2	3.01	1.13																								
40	17.3	2.99	1.15	12.1	3.61	1.36																					
45	19.3	2.94	1.18	13.4	3.49	1.42																					
50	21.4	2.93	1.18	14.7	3.41	1.48																					
55	23.5	2.92	1.19	16.1	3.38	1.50																					
60	25.5	2.89	1.21	17.5	3.35	1.52																					
65	27.6	2.89	1.21	18.8	3.30	1.56																					
70	29.7	2.89	1.21	20.2	3.28	1.57	14.4	3.98	1.81																		
75	31.7	2.87	1.23	21.6	3.27	1.58	15.3	3.91	1.86																		
80	33.8	2.87	1.23	23.0	3.26	1.58	16.3	3.90	1.87																		
90	38.0	2.87	1.23	25.8	3.25	1.60	18.1	3.80	1.94																		
100	42.1	2.85	1.24	28.6	3.23	1.61	20.0	3.76	1.98																		
110	46.3	2.85	1.24	31.4	3.22	1.62	21.9	3.73	2.01																		
120	50.4	2.84	1.25	34.1	3.20	1.64	23.9	3.73	2.00	17.0	4.47	2.34															
130	54.6	2.85	1.24	36.9	3.19	1.64	25.8	3.70	2.02	18.3	4.42	2.39															
140	58.7	2.84	1.25	39.7	3.19	1.65	27.7	3.68	2.04	19.6	4.37	2.43															
150	62.9	2.85	1.25	42.5	3.19	1.65	29.6	3.67	2.06	20.9	4.33	2.47															
160	67.0	2.84	1.25	45.3	3.18	1.65	31.6	3.68	2.05	22.2	4.30	2.50															
170	71.1	2.84	1.26	48.1	3.18	1.65	33.5	3.66	2.07	23.5	4.27	2.53	18.5	4.95	2.76												
180	75.3	2.84	1.25	50.9	3.18	1.66	35.4	3.65	2.08	24.8	4.24	2.55	19.5	4.90	2.80												
190	79.4	2.84	1.26	53.7	3.18	1.66	37.4	3.66	2.07	26.1	4.22	2.57	20.5	4.87	2.84												
200	83.5	2.84	1.26	56.5	3.18	1.66	39.3	3.65	2.08	27.5	4.23	2.56	21.5	4.83	2.87												
220	91.8	2.84	1.26	62.1	3.18	1.66	43.2	3.65	2.08	30.1	4.19	2.60	23.5	4.77	2.92												
240	100.0	2.83	1.26	67.6	3.17	1.67	47.0	3.63	2.10	32.7	4.15	2.64	25.5	4.72	2.97												
260	108.3	2.84	1.26	73.2	3.17	1.67	50.9	3.63	2.10	35.4	4.15	2.64	27.5	4.68	3.01	21.4	5.50	3.29									
280	116.6	2.84	1.26	78.8	3.17	1.67	54.8	3.63	2.10	38.1	4.14	2.64	29.5	4.64	3.05	22.9	5.44	3.35									
300	124.8	2.84	1.26	84.4	3.17	1.67	58.6	3.62	2.11	40.8	4.14	2.65	31.5	4.61	3.08	24.5	5.42	3.37									

Parabolic waterway design
(Retardance "D" and "B")

V_1 for <u>RETARDANCE "D"</u>. Top Width (T), Depth (D) and V_2 for <u>RETARDANCE "B"</u>.

Grade 0.50 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	10.2	2.28	0.95																								
20	13.3	2.18	1.02																								
25	16.5	2.15	1.05	10.5	2.60	1.35																					
30	19.7	2.12	1.06	12.4	2.51	1.42	9.5	2.91	1.60																		
35	22.8	2.09	1.09	14.3	2.45	1.48	10.9	2.81	1.69																		
40	26.0	2.08	1.09	16.3	2.44	1.49	12.3	2.74	1.76																		
45	29.2	2.08	1.10	18.2	2.41	1.52	13.7	2.69	1.81																		
50	32.4	2.08	1.10	20.2	2.40	1.53	15.1	2.64	1.86	11.1	3.22	2.07															
55	35.6	2.08	1.11	22.1	2.38	1.55	16.6	2.64	1.86	12.0	3.11	2.18															
60	38.8	2.08	1.11	24.1	2.38	1.55	18.0	2.61	1.90	13.0	3.07	2.23															
65	42.0	2.08	1.11	26.0	2.36	1.57	19.5	2.61	1.89	14.0	3.03	2.27															
70	45.2	2.08	1.11	28.0	2.36	1.57	20.9	2.59	1.92	15.0	3.01	2.31															
75	48.4	2.08	1.11	29.9	2.35	1.59	22.4	2.59	1.92	16.0	2.98	2.34	12.7	3.48	2.52												
80	51.6	2.08	1.11	31.9	2.36	1.58	23.8	2.58	1.94	17.0	2.96	2.36	13.4	3.41	2.60												
90	57.9	2.07	1.12	35.8	2.35	1.59	26.7	2.56	1.96	19.1	2.95	2.37	15.0	3.37	2.64												
100	64.3	2.07	1.11	39.7	2.34	1.60	29.6	2.55	1.97	21.1	2.92	2.42	16.5	3.31	2.72	13.3	3.77	2.96									
110	70.7	2.08	1.11	43.6	2.34	1.61	32.6	2.56	1.96	23.2	2.92	2.42	18.1	3.29	2.75	14.5	3.70	3.05									
120	77.0	2.07	1.12	47.5	2.33	1.61	35.5	2.56	1.97	25.2	2.89	2.45	19.6	3.24	2.81	15.7	3.64	3.12									
130	83.4	2.08	1.12	51.5	2.34	1.61	38.4	2.55	1.98	27.3	2.90	2.45	21.2	3.23	2.82	16.9	3.60	3.18									
140	89.7	2.08	1.12	55.4	2.34	1.61	41.3	2.55	1.98	29.3	2.88	2.47	22.8	3.22	2.84	18.1	3.56	3.23									
150	96.0	2.08	1.12	59.3	2.34	1.61	44.2	2.55	1.99	31.4	2.88	2.47	24.3	3.19	2.88	19.4	3.56	3.23	15.5	4.09	3.52						
160	102.3	2.08	1.12	63.2	2.34	1.61	47.1	2.54	1.99	33.5	2.89	2.47	25.9	3.19	2.88	20.6	3.53	3.27	16.4	4.02	3.60						
170	108.6	2.08	1.12	67.1	2.34	1.62	50.0	2.54	1.99	35.5	2.87	2.48	27.5	3.19	2.89	21.9	3.54	3.27	17.4	4.01	3.62						
180	114.9	2.08	1.12	70.9	2.33	1.62	52.9	2.54	1.99	37.6	2.88	2.48	29.1	3.19	2.89	23.1	3.51	3.30	18.3	3.96	3.69						
190	121.2	2.08	1.12	74.8	2.33	1.62	55.8	2.54	2.00	39.6	2.87	2.49	30.6	3.16	2.92	24.3	3.49	3.34	19.3	3.96	3.70						
200	127.4	2.08	1.13	78.7	2.33	1.62	58.7	2.54	2.00	41.7	2.87	2.49	32.2	3.16	2.93	25.6	3.50	3.33	20.2	3.91	3.77	16.8	4.48	3.96			
220	140.0	2.08	1.13	86.5	2.33	1.62	64.5	2.54	2.00	45.8	2.87	2.50	35.4	3.16	2.93	28.1	3.49	3.35	22.1	3.87	3.83	18.3	4.39	4.08			
240	152.6	2.08	1.13	94.3	2.33	1.63	70.3	2.54	2.01	49.9	2.86	2.51	38.6	3.16	2.93	30.6	3.48	3.36	24.1	3.87	3.84	19.9	4.36	4.12			
260	165.2	2.08	1.13	102.1	2.33	1.63	76.1	2.54	2.01	54.0	2.86	2.51	41.7	3.15	2.95	33.1	3.47	3.38	26.0	3.84	3.88	21.5	4.34	4.15			
280	177.7	2.08	1.13	109.8	2.33	1.63	81.9	2.54	2.01	58.2	2.87	2.50	44.9	3.15	2.95	35.6	3.46	3.39	28.0	3.84	3.88	23.0	4.28	4.24	19.0	4.88	4.50
300	190.3	2.08	1.13	117.6	2.33	1.63	87.7	2.54	2.01	62.3	2.86	2.51	48.0	3.14	2.97	38.1	3.45	3.40	29.9	3.82	3.92	24.6	4.27	4.26	20.2	4.80	4.61

Parabolic waterway design
(Retardance "D" and "B")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 0.75 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	13.7	1.76	0.92	8.0	2.22	1.24																					
20	18.2	1.75	0.93	10.4	2.10	1.35																					
25	22.6	1.73	0.95	12.8	2.03	1.42	9.5	2.33	1.66																		
30	27.1	1.73	0.95	15.3	2.02	1.44	11.2	2.25	1.76	8.9	2.56	1.94															
35	31.5	1.72	0.96	17.8	2.01	1.45	13.0	2.23	1.79	10.2	2.47	2.05															
40	36.0	1.72	0.96	20.2	1.98	1.48	14.8	2.21	1.81	11.6	2.44	2.09															
45	40.4	1.71	0.96	22.7	1.98	1.49	16.5	2.17	1.86	12.9	2.39	2.16															
50	44.9	1.72	0.96	25.2	1.98	1.49	18.3	2.16	1.87	14.3	2.38	2.18	10.6	2.82	2.47												
55	49.3	1.72	0.96	27.6	1.96	1.51	20.1	2.16	1.88	15.7	2.37	2.19	11.6	2.80	2.51												
60	53.7	1.72	0.97	30.1	1.96	1.51	21.9	2.16	1.89	17.1	2.36	2.20	12.5	2.73	2.61												
65	58.1	1.72	0.97	32.5	1.95	1.52	23.6	2.14	1.92	18.4	2.33	2.25	13.5	2.71	2.63	11.2	3.04	2.83									
70	62.5	1.72	0.97	35.0	1.96	1.52	25.4	2.14	1.92	19.8	2.33	2.25	14.4	2.66	2.71	12.0	3.01	2.87									
75	66.9	1.72	0.97	37.4	1.95	1.53	27.2	2.14	1.92	21.2	2.33	2.26	15.4	2.65	2.73	12.8	2.99	2.91									
80	71.2	1.71	0.97	39.9	1.95	1.53	29.0	2.14	1.92	22.5	2.31	2.29	16.4	2.65	2.74	13.5	2.92	3.01									
90	80.0	1.71	0.97	44.8	1.95	1.53	32.5	2.12	1.94	25.3	2.31	2.29	18.4	2.63	2.76	15.1	2.89	3.07	12.4	3.26	3.30						
100	88.8	1.72	0.98	49.7	1.95	1.54	36.1	2.13	1.94	28.1	2.31	2.29	20.4	2.62	2.78	16.7	2.86	3.11	13.7	3.22	3.36						
110	97.6	1.72	0.98	54.7	1.95	1.53	39.7	2.13	1.94	30.8	2.30	2.31	22.4	2.61	2.79	18.3	2.84	3.15	14.9	3.15	3.48						
120	106.3	1.72	0.98	59.6	1.95	1.54	43.2	2.12	1.95	33.6	2.30	2.31	24.4	2.61	2.81	19.9	2.82	3.18	16.2	3.13	3.52	13.4	3.49	3.81			
130	115.0	1.72	0.98	64.5	1.95	1.54	46.8	2.12	1.95	36.4	2.30	2.31	26.3	2.58	2.85	21.5	2.81	3.20	17.5	3.11	3.55	14.5	3.49	3.82			
140	123.7	1.72	0.98	69.4	1.95	1.54	50.3	2.12	1.96	39.1	2.29	2.33	28.3	2.58	2.85	23.1	2.80	3.22	18.7	3.07	3.63	15.5	3.44	3.91			
150	132.4	1.72	0.98	74.2	1.95	1.55	53.9	2.12	1.95	41.9	2.30	2.32	30.3	2.58	2.86	24.7	2.79	3.24	20.0	3.06	3.65	16.5	3.39	3.98			
160	141.1	1.72	0.98	79.1	1.95	1.55	57.4	2.12	1.96	44.6	2.29	2.33	32.3	2.58	2.86	26.3	2.78	3.26	21.3	3.05	3.67	17.6	3.39	3.98	14.4	3.77	4.37
170	149.7	1.72	0.98	84.0	1.95	1.55	60.9	2.12	1.97	47.4	2.30	2.33	34.3	2.58	2.86	28.0	2.80	3.24	22.6	3.04	3.68	18.6	3.36	4.05	15.3	3.77	4.38
180	158.3	1.72	0.98	88.8	1.95	1.55	64.5	2.12	1.96	50.1	2.29	2.34	36.3	2.58	2.86	29.6	2.79	3.25	23.9	3.04	3.69	19.6	3.33	4.11	16.1	3.73	4.46
190	166.9	1.72	0.98	93.7	1.95	1.55	68.0	2.12	1.97	52.8	2.29	2.34	38.3	2.58	2.86	31.2	2.78	3.26	25.2	3.03	3.70	20.7	3.33	4.10	17.0	3.73	4.45
200	175.5	1.72	0.99	98.5	1.95	1.55	71.5	2.12	1.97	55.6	2.29	2.34	40.2	2.57	2.89	32.8	2.78	3.27	26.5	3.03	3.71	21.7	3.31	4.15	17.8	3.70	4.52
220	192.8	1.72	0.99	108.3	1.95	1.55	78.6	2.12	1.97	61.1	2.29	2.34	44.2	2.57	2.89	36.0	2.77	3.29	29.1	3.02	3.73	23.8	3.29	4.18	19.5	3.67	4.58
240	210.1	1.72	0.99	118.0	1.95	1.56	85.6	2.12	1.98	66.6	2.29	2.35	48.2	2.57	2.89	39.2	2.76	3.31	31.7	3.01	3.75	25.9	3.28	4.22	21.2	3.64	4.63
260	227.3	1.72	0.99	127.7	1.95	1.56	92.7	2.12	1.98	72.1	2.29	2.35	52.2	2.57	2.89	42.5	2.77	3.30	34.3	3.01	3.76	28.0	3.26	4.24	22.9	3.62	4.67
280	244.5	1.72	0.99	137.4	1.95	1.56	99.7	2.12	1.98	77.6	2.29	2.35	56.2	2.57	2.89	45.7	2.76	3.31	36.9	3.00	3.77	30.1	3.25	4.26	24.7	3.63	4.65
300	261.7	1.72	0.99	147.1	1.95	1.56	106.8	2.12	1.98	83.0	2.29	2.36	60.1	2.57	2.90	48.9	2.76	3.32	39.5	3.00	3.78	32.2	3.25	4.28	26.4	3.62	4.68

Parabolic waterway design
(Retardance "D" and "B")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 1.0 Percent

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	15.7	1.55	0.91	9.9	1.80	1.24																					
20	20.9	1.54	0.92	13.0	1.74	1.31	8.8	2.04	1.65																		
25	26.0	1.53	0.93	16.2	1.73	1.32	10.9	1.99	1.70	8.9	2.21	1.87															
30	31.1	1.52	0.94	19.3	1.70	1.35	12.9	1.94	1.78	10.5	2.14	1.98															
35	36.2	1.52	0.94	22.5	1.70	1.36	15.0	1.93	1.80	12.1	2.08	2.06	9.2	2.37	2.37												
40	41.3	1.52	0.95	25.7	1.70	1.36	17.1	1.92	1.81	13.7	2.04	2.12	10.4	2.32	2.45												
45	46.4	1.52	0.95	28.8	1.69	1.37	19.2	1.91	1.82	15.4	2.04	2.12	11.7	2.32	2.46												
50	51.5	1.52	0.95	32.0	1.70	1.37	21.2	1.89	1.85	17.0	2.02	2.16	12.9	2.28	2.52	9.9	2.61	2.86									
55	56.5	1.51	0.95	35.1	1.69	1.38	23.3	1.89	1.86	18.7	2.02	2.16	14.1	2.25	2.57	10.8	2.57	2.93									
60	61.6	1.52	0.95	38.3	1.69	1.37	25.4	1.89	1.86	20.3	2.00	2.19	15.3	2.23	2.61	11.7	2.54	3.00									
65	66.6	1.52	0.96	41.4	1.69	1.38	27.5	1.89	1.86	22.0	2.01	2.19	16.6	2.24	2.60	12.7	2.55	2.98	10.6	2.88	3.16						
70	71.6	1.51	0.96	44.6	1.70	1.38	29.5	1.88	1.88	23.6	1.99	2.21	17.8	2.22	2.63	13.6	2.52	3.03	11.3	2.82	3.26						
75	76.6	1.51	0.96	47.7	1.69	1.38	31.6	1.88	1.88	25.3	2.00	2.21	19.0	2.21	2.66	14.5	2.50	3.08	12.0	2.77	3.35						
80	81.6	1.52	0.96	50.8	1.69	1.38	33.7	1.88	1.88	26.9	1.99	2.22	20.3	2.22	2.64	15.4	2.48	3.11	12.7	2.73	3.43						
90	91.7	1.52	0.96	57.1	1.69	1.39	37.8	1.88	1.89	30.2	1.98	2.24	22.8	2.21	2.65	17.3	2.47	3.13	14.2	2.69	3.49	11.8	2.99	3.78			
100	101.7	1.52	0.96	63.4	1.69	1.39	42.0	1.88	1.89	33.5	1.98	2.24	25.2	2.19	2.69	19.2	2.47	3.14	15.7	2.67	3.55	13.0	2.94	3.88			
110	111.7	1.52	0.97	69.6	1.69	1.39	46.1	1.87	1.90	36.8	1.98	2.25	27.7	2.19	2.70	21.0	2.44	3.20	17.3	2.68	3.53	14.3	2.94	3.88	12.4	3.23	4.07
120	121.7	1.52	0.97	75.8	1.69	1.39	50.2	1.87	1.90	40.1	1.98	2.26	30.2	2.19	2.70	22.9	2.44	3.20	18.8	2.66	3.57	15.5	2.91	3.96	13.4	3.17	4.19
130	131.6	1.51	0.97	82.1	1.69	1.39	54.4	1.87	1.90	43.4	1.97	2.26	32.7	2.19	2.70	24.8	2.44	3.20	20.3	2.64	3.61	16.7	2.88	4.03	14.4	3.12	4.30
140	141.5	1.51	0.97	88.3	1.69	1.39	58.5	1.87	1.90	46.7	1.97	2.26	35.2	2.19	2.70	26.6	2.42	3.24	21.8	2.63	3.64	17.9	2.85	4.08	15.5	3.12	4.31
150	151.4	1.52	0.97	94.5	1.69	1.40	62.6	1.87	1.91	50.0	1.98	2.26	37.6	2.18	2.72	28.5	2.42	3.23	23.3	2.62	3.66	19.2	2.86	4.07	16.5	3.08	4.39
160	161.3	1.52	0.97	100.7	1.69	1.40	66.7	1.87	1.91	53.3	1.98	2.26	40.1	2.18	2.72	30.4	2.43	3.23	24.8	2.61	3.68	20.4	2.84	4.11	17.6	3.08	4.39
170	171.1	1.52	0.97	106.8	1.69	1.40	70.8	1.87	1.91	56.5	1.97	2.28	42.6	2.19	2.72	32.2	2.41	3.26	26.3	2.60	3.70	21.7	2.85	4.10	18.6	3.05	4.46
180	180.9	1.52	0.98	113.0	1.69	1.40	74.9	1.87	1.91	59.8	1.97	2.27	45.0	2.18	2.73	34.1	2.42	3.25	27.9	2.61	3.68	22.9	2.83	4.14	19.6	3.02	4.52
190	190.6	1.52	0.98	119.1	1.69	1.40	79.0	1.87	1.91	63.1	1.98	2.27	47.5	2.18	2.73	35.9	2.41	3.27	29.4	2.61	3.69	24.1	2.81	4.17	20.7	3.03	4.51
200	200.4	1.52	0.98	125.3	1.69	1.40	83.0	1.87	1.92	66.3	1.97	2.28	49.9	2.18	2.74	37.8	2.41	3.27	30.9	2.60	3.71	25.4	2.82	4.15	21.7	3.00	4.57
220	220.1	1.52	0.98	137.6	1.69	1.41	91.2	1.87	1.92	72.9	1.97	2.28	54.9	2.18	2.74	41.5	2.41	3.28	33.9	2.59	3.73	27.9	2.82	4.17	23.8	2.99	4.61
240	239.8	1.52	0.98	150.0	1.69	1.41	99.4	1.87	1.93	79.5	1.98	2.28	59.8	2.18	2.75	45.3	2.41	3.28	37.0	2.60	3.72	30.4	2.81	4.18	25.9	2.97	4.64
260	259.4	1.52	0.98	162.3	1.69	1.41	107.6	1.87	1.93	86.0	1.97	2.28	64.8	2.18	2.74	49.0	2.41	3.29	40.0	2.59	3.75	32.9	2.81	4.20	28.0	2.96	4.67
280	279.0	1.52	0.98	174.6	1.70	1.41	115.8	1.87	1.93	92.5	1.97	2.29	69.7	2.18	2.75	52.7	2.40	3.30	43.0	2.58	3.76	35.3	2.79	4.24	30.2	2.97	4.65
300	298.5	1.52	0.98	186.9	1.70	1.41	123.9	1.87	1.93	99.1	1.98	2.29	74.6	2.18	2.75	56.4	2.40	3.30	46.1	2.59	3.75	37.8	2.79	4.24	32.3	2.97	4.67

Parabolic waterway design
(Retardance "D" and "B")

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 1.25 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	18.1	1.40	0.88	11.5	1.59	1.21	7.7	1.85	1.55																		
20	24.0	1.38	0.89	15.2	1.56	1.25	10.1	1.79	1.64	7.7	2.03	1.89															
25	30.0	1.38	0.89	19.0	1.56	1.25	12.5	1.75	1.69	9.5	1.97	1.97	7.8	2.19	2.16												
30	35.9	1.38	0.90	22.7	1.55	1.27	14.9	1.73	1.73	11.2	1.90	2.09	9.2	2.11	2.28												
35	41.8	1.38	0.90	26.4	1.54	1.28	17.3	1.71	1.75	13.0	1.88	2.12	10.5	2.02	2.44	8.3	2.36	2.64									
40	47.7	1.38	0.90	30.1	1.54	1.28	19.7	1.70	1.77	14.8	1.87	2.15	12.0	2.02	2.44	9.4	2.32	2.72									
45	53.6	1.38	0.90	33.9	1.54	1.28	22.1	1.69	1.78	16.6	1.86	2.17	13.4	1.99	2.50	10.5	2.28	2.78									
50	59.4	1.38	0.91	37.6	1.54	1.28	24.5	1.69	1.79	18.4	1.85	2.18	14.9	1.99	2.50	11.5	2.22	2.90	9.4	2.49	3.16						
55	65.3	1.38	0.91	41.3	1.54	1.28	26.9	1.69	1.80	20.2	1.84	2.19	16.3	1.97	2.54	12.6	2.20	2.94	10.3	2.47	3.20						
60	71.1	1.38	0.91	44.9	1.53	1.29	29.3	1.68	1.81	22.0	1.84	2.20	17.7	1.96	2.57	13.7	2.19	2.97	11.2	2.45	3.23						
65	76.9	1.38	0.91	48.6	1.54	1.29	31.7	1.68	1.81	23.7	1.82	2.24	19.2	1.97	2.56	14.8	2.18	2.99	12.0	2.40	3.34	9.8	2.76	3.55			
70	82.7	1.38	0.91	52.3	1.54	1.29	34.1	1.68	1.81	25.5	1.82	2.24	20.6	1.95	2.58	15.9	2.17	3.01	12.9	2.39	3.36	10.5	2.74	3.61			
75	88.4	1.38	0.91	55.9	1.53	1.30	36.5	1.68	1.82	27.3	1.82	2.24	22.1	1.96	2.57	17.0	2.16	3.03	13.8	2.39	3.38	11.1	2.67	3.76			
80	94.2	1.38	0.91	59.6	1.54	1.30	38.9	1.68	1.82	29.1	1.82	2.24	23.5	1.95	2.59	18.1	2.16	3.05	14.7	2.38	3.39	11.8	2.65	3.80	10.3	2.92	3.94
90	105.8	1.38	0.91	66.9	1.53	1.30	43.7	1.68	1.82	32.7	1.82	2.25	26.4	1.95	2.60	20.3	2.14	3.07	16.4	2.34	3.48	13.2	2.62	3.87	11.4	2.83	4.14
100	117.3	1.38	0.92	74.3	1.54	1.30	48.5	1.68	1.83	36.3	1.82	2.25	29.3	1.95	2.61	22.5	2.14	3.10	18.2	2.34	3.49	14.6	2.59	3.92	12.6	2.80	4.21
110	128.9	1.38	0.92	81.6	1.54	1.31	53.3	1.68	1.83	39.8	1.81	2.27	32.2	1.95	2.61	24.7	2.13	3.11	20.0	2.34	3.50	16.0	2.58	3.97	13.8	2.77	4.27
120	140.4	1.38	0.92	88.9	1.54	1.31	58.1	1.68	1.83	43.4	1.81	2.27	35.0	1.94	2.64	26.9	2.12	3.13	21.7	2.31	3.56	17.4	2.56	4.00	15.0	2.75	4.32
130	151.8	1.38	0.92	96.1	1.53	1.31	62.9	1.68	1.83	47.0	1.82	2.27	37.9	1.94	2.64	29.1	2.12	3.14	23.5	2.31	3.56	18.8	2.55	4.04	16.2	2.74	4.36
140	163.2	1.38	0.92	103.4	1.54	1.31	67.6	1.68	1.84	50.5	1.81	2.28	40.8	1.94	2.64	31.3	2.12	3.14	25.3	2.31	3.56	20.2	2.54	4.06	17.4	2.72	4.39
150	174.6	1.38	0.92	110.6	1.53	1.31	72.4	1.68	1.83	54.1	1.81	2.28	43.7	1.94	2.64	33.5	2.12	3.15	27.0	2.30	3.60	21.6	2.53	4.08	18.6	2.71	4.42
160	186.0	1.38	0.92	117.8	1.53	1.32	77.1	1.68	1.84	57.6	1.81	2.29	46.5	1.93	2.65	35.7	2.12	3.16	28.8	2.30	3.60	22.9	2.50	4.16	19.8	2.70	4.45
170	197.3	1.39	0.92	125.0	1.54	1.32	81.9	1.68	1.84	61.2	1.81	2.28	49.4	1.94	2.65	37.9	2.12	3.16	30.6	2.30	3.59	24.3	2.50	4.17	21.0	2.69	4.47
180	208.5	1.38	0.93	132.2	1.54	1.32	86.6	1.68	1.84	64.7	1.81	2.29	52.2	1.93	2.66	40.1	2.12	3.16	32.3	2.29	3.62	25.7	2.49	4.18	22.2	2.69	4.49
190	219.8	1.39	0.93	139.3	1.54	1.32	91.3	1.68	1.84	68.2	1.81	2.29	55.1	1.94	2.65	42.3	2.12	3.16	34.1	2.30	3.62	27.1	2.49	4.19	23.4	2.68	4.51
200	231.0	1.39	0.93	146.5	1.54	1.32	96.0	1.68	1.84	71.8	1.82	2.29	57.9	1.93	2.66	44.5	2.12	3.17	35.8	2.29	3.64	28.5	2.49	4.20	24.6	2.68	4.52
220	253.7	1.39	0.93	160.9	1.54	1.32	105.5	1.68	1.84	78.9	1.82	2.29	63.7	1.94	2.66	48.9	2.12	3.17	39.4	2.29	3.63	31.3	2.48	4.22	27.0	2.67	4.55
240	276.3	1.39	0.93	175.3	1.54	1.33	115.0	1.69	1.84	85.9	1.81	2.30	69.4	1.94	2.66	53.3	2.11	3.18	42.9	2.29	3.65	34.1	2.48	4.23	29.4	2.66	4.57
260	298.9	1.39	0.93	189.7	1.54	1.33	124.4	1.68	1.85	93.0	1.81	2.30	75.1	1.93	2.67	57.6	2.11	3.19	46.5	2.29	3.64	36.9	2.48	4.24	31.8	2.65	4.59
280	321.3	1.39	0.93	204.0	1.54	1.33	133.9	1.69	1.85	100.1	1.82	2.30	80.8	1.93	2.67	62.0	2.11	3.19	50.0	2.29	3.65	39.7	2.47	4.25	34.2	2.65	4.61
300	343.7	1.39	0.93	218.2	1.54	1.33	143.3	1.69	1.85	107.1	1.81	2.30	86.5	1.94	2.67	66.4	2.11	3.19	53.5	2.28	3.66	42.5	2.47	4.26	36.6	2.65	4.62

Parabolic waterway design
(Retardance "D" and "B")

4-26467 5-68

V_1 for <u>RETARDANCE "D"</u>. Top Width (T), Depth (D) and V_2 for <u>RETARDANCE "B"</u>.

Grade 1.50 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	20.1	1.29	0.86	13.2	1.43	1.17	8.9	1.65	1.51																		
20	26.8	1.29	0.86	17.5	1.42	1.19	11.7	1.60	1.58	8.1	1.86	1.95	6.7	2.09	2.10												
25	33.4	1.28	0.86	21.8	1.41	1.21	14.5	1.57	1.63	9.9	1.78	2.10	8.1	1.95	2.34												
30	40.0	1.28	0.87	26.2	1.42	1.20	17.4	1.57	1.63	11.8	1.75	2.15	9.6	1.90	2.43	8.0	2.13	2.60									
35	46.5	1.28	0.87	30.5	1.41	1.21	20.2	1.56	1.65	13.7	1.74	2.18	11.1	1.86	2.50	9.2	2.06	2.72									
40	53.1	1.28	0.87	34.8	1.41	1.21	23.0	1.55	1.67	15.6	1.73	2.20	12.6	1.84	2.56	10.4	2.02	2.82	8.2	2.38	3.03						
45	59.6	1.28	0.88	39.0	1.40	1.22	25.9	1.55	1.66	17.5	1.72	2.22	14.2	1.85	2.55	11.7	2.02	2.82	9.1	2.31	3.16						
50	66.1	1.28	0.88	43.3	1.41	1.22	28.7	1.55	1.67	19.4	1.71	2.24	15.7	1.83	2.58	12.9	1.99	2.89	10.0	2.26	3.27						
55	72.6	1.28	0.88	47.6	1.41	1.22	31.5	1.55	1.68	21.3	1.71	2.25	17.2	1.82	2.61	14.2	1.99	2.89	10.9	2.22	3.36	9.3	2.47	3.54			
60	79.0	1.28	0.88	51.8	1.41	1.22	34.3	1.54	1.69	23.2	1.70	2.25	18.8	1.82	2.60	15.4	1.97	2.94	11.9	2.22	3.36	10.1	2.45	3.59			
65	85.5	1.28	0.88	56.0	1.40	1.23	37.1	1.54	1.69	25.1	1.70	2.26	20.3	1.82	2.62	16.6	1.95	2.98	12.8	2.19	3.43	10.8	2.39	3.73			
70	91.9	1.28	0.88	60.3	1.41	1.22	39.9	1.54	1.69	27.0	1.70	2.26	21.8	1.81	2.64	17.9	1.96	2.96	13.8	2.20	3.42	11.6	2.38	3.76	9.8	2.62	4.03
75	98.2	1.28	0.89	64.5	1.41	1.23	42.7	1.54	1.69	28.9	1.70	2.27	23.3	1.80	2.66	19.1	1.95	3.00	14.7	2.18	3.48	12.4	2.37	3.79	10.5	2.62	4.04
80	104.6	1.28	0.89	68.7	1.41	1.23	45.5	1.54	1.70	30.8	1.70	2.27	24.9	1.81	2.64	20.4	1.95	2.98	15.7	2.18	3.46	13.2	2.36	3.81	11.1	2.58	4.15
90	117.5	1.28	0.89	77.1	1.41	1.23	51.1	1.54	1.70	34.6	1.70	2.28	27.9	1.80	2.67	22.9	1.95	3.00	17.6	2.17	3.50	14.7	2.31	3.93	12.4	2.54	4.24
100	130.3	1.28	0.89	85.6	1.41	1.23	56.7	1.54	1.70	38.3	1.69	2.30	31.0	1.80	2.66	25.4	1.94	3.02	19.5	2.16	3.53	16.3	2.30	3.96	13.7	2.51	4.32
110	143.0	1.28	0.89	94.0	1.41	1.24	62.3	1.54	1.71	42.1	1.69	2.30	34.0	1.79	2.68	27.9	1.94	3.03	21.4	2.15	3.56	17.9	2.30	3.98	15.0	2.49	4.38
120	155.8	1.28	0.89	102.4	1.41	1.24	67.9	1.54	1.71	45.9	1.69	2.30	37.1	1.80	2.68	30.4	1.94	3.03	23.3	2.14	3.57	19.5	2.29	3.99	16.3	2.47	4.43
130	168.4	1.28	0.90	110.7	1.41	1.24	73.4	1.54	1.71	49.7	1.69	2.30	40.1	1.79	2.69	32.9	1.94	3.04	25.2	2.14	3.59	21.1	2.29	4.01	17.6	2.45	4.48
140	181.0	1.28	0.90	119.1	1.41	1.24	79.0	1.54	1.71	53.4	1.69	2.31	43.2	1.80	2.68	35.3	1.93	3.07	27.1	2.14	3.60	22.7	2.29	4.02	18.9	2.44	4.51
150	193.6	1.28	0.90	127.4	1.41	1.24	84.5	1.54	1.72	57.2	1.69	2.31	46.2	1.79	2.70	37.8	1.93	3.07	29.0	2.13	3.61	24.2	2.27	4.07	20.2	2.43	4.54
160	206.2	1.28	0.90	135.7	1.41	1.24	90.0	1.54	1.72	60.9	1.69	2.32	49.3	1.80	2.69	40.3	1.93	3.07	30.9	2.13	3.62	25.8	2.27	4.08	21.6	2.45	4.51
170	218.6	1.28	0.90	144.0	1.41	1.24	95.6	1.54	1.72	64.7	1.69	2.31	52.3	1.80	2.69	42.8	1.93	3.07	32.8	2.13	3.62	27.4	2.27	4.08	22.9	2.44	4.53
180	231.1	1.28	0.90	152.2	1.41	1.25	101.0	1.54	1.72	68.4	1.69	2.32	55.3	1.80	2.70	45.3	1.93	3.07	34.7	2.13	3.63	29.0	2.27	4.08	24.2	2.43	4.56
190	243.5	1.28	0.90	160.4	1.41	1.25	106.5	1.54	1.72	72.1	1.69	2.32	58.3	1.80	2.71	47.7	1.92	3.08	36.5	2.12	3.66	30.6	2.27	4.08	25.5	2.42	4.58
200	255.8	1.23	0.91	168.6	1.41	1.25	112.0	1.54	1.72	75.9	1.69	2.32	61.3	1.79	2.71	50.2	1.93	3.08	38.4	2.12	3.66	32.1	2.26	4.12	26.8	2.42	4.60
220	280.9	1.28	0.91	185.2	1.41	1.25	123.0	1.54	1.73	83.4	1.69	2.32	67.4	1.80	2.71	55.2	1.93	3.08	42.2	2.12	3.67	35.3	2.26	4.12	29.5	2.42	4.58
240	305.8	1.28	0.91	201.7	1.41	1.25	134.1	1.54	1.73	90.9	1.69	2.32	73.5	1.80	2.71	60.1	1.92	3.09	46.0	2.12	3.67	38.5	2.26	4.12	32.1	2.41	4.62
260	330.7	1.28	0.91	218.2	1.41	1.26	145.1	1.54	1.73	98.3	1.69	2.33	79.5	1.80	2.72	65.1	1.93	3.09	49.8	2.12	3.68	41.7	2.26	4.12	34.7	2.41	4.64
280	355.5	1.28	0.91	234.7	1.41	1.26	156.0	1.54	1.73	105.8	1.69	2.33	85.5	1.79	2.72	70.0	1.93	3.10	53.6	2.12	3.68	44.8	2.25	4.14	37.4	2.41	4.63
300	380.2	1.28	0.91	251.1	1.41	1.26	167.0	1.54	1.73	113.2	1.69	2.33	91.6	1.80	2.72	74.9	1.92	3.11	57.4	2.12	3.68	48.0	2.25	4.14	40.0	2.41	4.65

Parabolic waterway design
(Retardance "D" and "B")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B"

Grade 1.75 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	21.8	1.21	0.84	14.2	1.33	1.17	10.0	1.50	1.48	6.9	1.74	1.84															
20	29.0	1.20	0.85	18.9	1.33	1.18	13.2	1.46	1.53	9.0	1.66	1.98	7.6	1.83	2.12												
25	36.2	1.20	0.85	23.5	1.32	1.20	16.4	1.45	1.56	11.2	1.64	2.01	9.3	1.75	2.27	7.6	1.93	2.51									
30	43.4	1.21	0.85	28.2	1.32	1.20	19.6	1.44	1.58	13.3	1.60	2.08	11.1	1.72	2.32	9.0	1.88	2.62									
35	50.5	1.20	0.85	32.8	1.31	1.21	22.8	1.43	1.59	15.5	1.60	2.09	12.8	1.68	2.40	10.4	1.84	2.70	8.2	2.11	2.98						
40	57.6	1.20	0.85	37.4	1.31	1.21	26.0	1.43	1.60	17.6	1.58	2.13	14.6	1.68	2.42	11.8	1.81	2.77	9.3	2.08	3.06						
45	64.6	1.20	0.86	42.0	1.31	1.21	29.2	1.43	1.61	19.8	1.58	2.13	16.4	1.68	2.43	13.2	1.79	2.82	10.3	2.01	3.21	8.6	2.26	3.41			
50	71.6	1.20	0.86	46.6	1.31	1.21	32.4	1.43	1.61	21.9	1.57	2.16	18.2	1.67	2.44	14.7	1.80	2.80	11.4	2.00	3.25	9.5	2.24	3.48			
55	78.6	1.20	0.86	51.2	1.31	1.22	35.6	1.43	1.61	24.1	1.58	2.15	19.9	1.66	2.48	16.1	1.79	2.83	12.5	1.99	3.28	10.3	2.17	3.64	8.6	2.51	3.77
60	85.6	1.20	0.87	55.8	1.31	1.22	38.8	1.43	1.61	26.2	1.57	2.17	21.7	1.66	2.48	17.5	1.78	2.86	13.6	1.98	3.31	11.2	2.16	3.67	9.2	2.41	4.00
65	92.6	1.20	0.87	60.3	1.31	1.22	41.9	1.42	1.62	28.4	1.57	2.16	23.5	1.66	2.48	18.9	1.77	2.88	14.7	1.97	3.33	12.1	2.15	3.70	9.9	2.38	4.08
70	99.5	1.20	0.87	64.9	1.32	1.22	45.1	1.42	1.62	30.5	1.57	2.18	25.2	1.65	2.50	20.3	1.76	2.90	15.8	1.96	3.35	13.0	2.14	3.73	10.6	2.35	4.15
75	106.4	1.20	0.87	69.4	1.31	1.22	48.2	1.42	1.63	32.7	1.57	2.17	27.0	1.65	2.50	21.8	1.78	2.88	16.9	1.96	3.36	13.9	2.13	3.75	11.4	2.37	4.11
80	113.3	1.20	0.87	73.9	1.31	1.22	51.4	1.43	1.62	34.8	1.57	2.18	28.8	1.66	2.50	23.2	1.77	2.90	17.9	1.94	3.43	14.8	2.13	3.77	12.1	2.35	4.17
90	127.2	1.20	0.87	83.0	1.31	1.23	57.7	1.42	1.63	39.1	1.57	2.18	32.3	1.65	2.52	26.0	1.76	2.93	20.1	1.93	3.45	16.6	2.12	3.81	13.5	2.31	4.28
100	141.0	1.20	0.87	92.1	1.32	1.23	64.0	1.42	1.64	43.4	1.57	2.18	35.8	1.64	2.53	28.9	1.76	2.92	22.3	1.93	3.46	18.4	2.11	3.83	14.9	2.28	4.37
110	154.9	1.21	0.87	101.2	1.32	1.23	70.4	1.43	1.63	47.7	1.57	2.19	39.4	1.65	2.52	31.7	1.76	2.94	24.5	1.92	3.47	20.1	2.08	3.91	16.4	2.29	4.36
120	168.6	1.20	0.88	110.2	1.32	1.23	76.6	1.42	1.64	51.9	1.57	2.20	42.9	1.64	2.53	34.6	1.76	2.93	26.7	1.92	3.48	21.9	2.08	3.93	17.8	2.26	4.43
130	182.3	1.21	0.88	119.2	1.32	1.23	82.9	1.42	1.64	56.2	1.57	2.20	46.4	1.64	2.54	37.4	1.76	2.95	28.9	1.92	3.49	23.7	2.07	3.93	19.2	2.25	4.48
140	196.0	1.21	0.88	128.1	1.32	1.23	89.2	1.43	1.64	60.4	1.57	2.21	49.9	1.64	2.55	40.2	1.75	2.96	31.1	1.92	3.49	25.5	2.07	3.94	20.7	2.25	4.47
150	209.6	1.21	0.88	137.1	1.32	1.23	95.4	1.42	1.64	64.7	1.57	2.20	53.4	1.64	2.55	43.1	1.76	2.95	33.3	1.92	3.49	27.3	2.07	3.95	22.1	2.24	4.51
160	223.1	1.21	0.88	146.0	1.32	1.24	101.6	1.42	1.65	68.9	1.57	2.21	56.9	1.64	2.55	45.9	1.76	2.96	35.4	1.91	3.52	29.1	2.07	3.95	23.6	2.25	4.49
170	236.6	1.21	0.88	154.9	1.32	1.24	107.9	1.43	1.64	73.1	1.57	2.21	60.4	1.64	2.55	48.7	1.76	2.96	37.6	1.91	3.52	30.9	2.07	3.95	25.0	2.24	4.53
180	250.0	1.21	0.89	163.7	1.32	1.24	114.0	1.43	1.65	77.4	1.57	2.21	63.9	1.64	2.55	51.5	1.75	2.97	39.8	1.92	3.52	32.6	2.06	3.99	26.4	2.23	4.56
190	263.4	1.21	0.89	172.6	1.32	1.24	120.2	1.43	1.65	81.6	1.57	2.21	67.4	1.64	2.55	54.3	1.75	2.97	42.0	1.92	3.52	34.4	2.06	3.99	27.9	2.23	4.54
200	276.7	1.21	0.89	181.4	1.32	1.24	126.4	1.43	1.65	85.7	1.57	2.22	70.8	1.64	2.56	57.1	1.75	2.98	44.1	1.91	3.54	36.2	2.06	3.99	29.3	2.23	4.57
220	303.8	1.21	0.89	199.2	1.32	1.24	138.8	1.43	1.65	94.2	1.57	2.22	77.8	1.64	2.57	62.8	1.76	2.97	48.5	1.91	3.53	39.8	2.07	3.99	32.2	2.22	4.58
240	330.8	1.21	0.89	217.0	1.32	1.24	151.2	1.43	1.66	102.7	1.57	2.22	84.8	1.64	2.57	68.4	1.75	2.98	52.9	1.92	3.53	43.3	2.06	4.02	35.1	2.22	4.58
260	357.7	1.21	0.89	234.7	1.32	1.25	163.6	1.43	1.66	111.1	1.57	2.22	91.8	1.64	2.57	74.1	1.76	2.98	57.2	1.91	3.54	46.9	2.06	4.01	38.0	2.22	4.59
280	384.5	1.21	0.89	252.3	1.32	1.25	176.0	1.43	1.66	119.5	1.57	2.23	98.7	1.64	2.58	79.7	1.76	2.98	61.6	1.92	3.54	50.5	2.06	4.01	40.9	2.22	4.59
300	411.2	1.21	0.90	269.9	1.32	1.25	188.3	1.43	1.66	127.9	1.57	2.23	105.7	1.64	2.57	85.3	1.76	2.99	65.9	1.91	3.55	54.0	2.06	4.03	43.7	2.21	4.62

Parabolic waterway design
(Retardance "D" and "B")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 2.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	24.7	1.14	0.79	15.0	1.25	1.18	11.0	1.40	1.43	7.8	1.56	1.81															
20	32.8	1.14	0.79	20.0	1.25	1.18	14.5	1.37	1.49	10.3	1.53	1.88	7.5	1.71	2.29	6.3	1.91	2.44									
25	41.0	1.14	0.79	24.9	1.24	1.20	18.1	1.37	1.50	12.7	1.48	1.96	9.3	1.68	2.36	7.7	1.82	2.62									
30	49.0	1.14	0.80	29.8	1.24	1.20	21.6	1.35	1.52	15.2	1.48	1.98	11.0	1.63	2.47	9.1	1.77	2.76	7.6	1.97	2.95						
35	57.1	1.14	0.80	34.7	1.24	1.21	25.1	1.35	1.54	17.7	1.47	1.99	12.8	1.62	2.50	10.5	1.73	2.86	8.8	1.94	3.03						
40	65.1	1.14	0.80	39.6	1.24	1.21	28.7	1.35	1.53	20.2	1.47	2.00	14.6	1.62	2.51	12.0	1.73	2.86	9.9	1.88	3.18	8.2	2.13	3.38			
45	73.1	1.14	0.80	44.5	1.24	1.21	32.2	1.35	1.54	22.6	1.46	2.03	16.4	1.61	2.52	13.5	1.73	2.86	11.1	1.87	3.21	9.1	2.08	3.52			
50	81.0	1.14	0.81	49.3	1.24	1.22	35.7	1.35	1.55	25.1	1.46	2.03	18.1	1.59	2.57	14.9	1.71	2.92	12.3	1.86	3.24	10.0	2.03	3.64	8.6	2.29	3.76
55	88.9	1.14	0.81	54.2	1.24	1.21	39.2	1.34	1.55	27.6	1.46	2.03	19.9	1.60	2.57	16.4	1.71	2.91	13.5	1.85	3.26	11.0	2.03	3.65	9.3	2.21	3.96
60	96.8	1.14	0.81	59.0	1.24	1.22	42.7	1.34	1.55	30.0	1.45	2.05	21.7	1.60	2.57	17.8	1.69	2.95	14.7	1.85	3.28	11.9	2.00	3.74	10.1	2.19	4.01
65	104.6	1.14	0.81	63.8	1.24	1.22	46.2	1.35	1.55	32.5	1.46	2.04	23.4	1.58	2.60	19.3	1.70	2.94	15.8	1.82	3.36	12.9	2.00	3.73	10.9	2.18	4.06
70	112.4	1.14	0.81	68.6	1.24	1.22	49.7	1.35	1.56	34.9	1.45	2.05	25.2	1.59	2.60	20.7	1.69	2.98	17.0	1.82	3.36	13.8	1.98	3.81	11.7	2.16	4.10
75	120.2	1.14	0.81	73.4	1.24	1.22	53.1	1.34	1.56	37.3	1.45	2.06	27.0	1.59	2.60	22.2	1.69	2.96	18.2	1.82	3.37	14.8	1.98	3.79	12.5	2.15	4.14
80	127.9	1.14	0.82	78.1	1.24	1.23	56.6	1.35	1.56	39.8	1.45	2.06	28.7	1.58	2.62	23.6	1.69	2.99	19.4	1.82	3.37	15.8	1.99	3.78	13.3	2.14	4.17
90	143.6	1.14	0.82	87.8	1.24	1.23	63.5	1.34	1.57	44.7	1.45	2.06	32.3	1.59	2.61	26.5	1.68	3.00	21.8	1.82	3.38	17.7	1.97	3.83	14.9	2.12	4.22
100	159.2	1.14	0.82	97.4	1.24	1.23	70.5	1.34	1.57	49.6	1.45	2.07	35.8	1.58	2.63	29.4	1.68	3.01	24.1	1.80	3.43	19.6	1.96	3.87	16.5	2.11	4.26
110	174.8	1.14	0.82	106.9	1.24	1.23	77.4	1.34	1.57	54.5	1.45	2.07	39.3	1.58	2.64	32.3	1.68	3.02	26.5	1.80	3.43	21.5	1.95	3.90	18.1	2.10	4.30
120	190.3	1.14	0.82	116.5	1.24	1.23	84.3	1.34	1.58	59.4	1.45	2.07	42.8	1.58	2.65	35.2	1.68	3.02	28.9	1.80	3.43	23.4	1.94	3.92	19.7	2.09	4.33
130	205.7	1.14	0.82	126.0	1.24	1.23	91.2	1.34	1.58	64.2	1.45	2.08	46.4	1.58	2.64	38.1	1.68	3.03	31.3	1.80	3.43	25.4	1.95	3.90	21.3	2.09	4.35
140	221.0	1.14	0.82	135.4	1.24	1.24	98.0	1.34	1.58	69.1	1.45	2.08	49.9	1.58	2.64	41.0	1.68	3.03	33.6	1.80	3.46	27.3	1.95	3.92	22.9	2.08	4.37
150	236.3	1.14	0.83	144.9	1.25	1.24	104.9	1.34	1.58	73.9	1.45	2.08	53.4	1.58	2.65	43.9	1.68	3.03	36.0	1.80	3.45	29.2	1.95	3.93	24.5	2.08	4.38
160	251.5	1.14	0.83	154.3	1.25	1.24	111.7	1.34	1.59	78.7	1.45	2.09	56.9	1.58	2.65	46.7	1.67	3.05	38.3	1.79	3.47	31.1	1.94	3.94	26.1	2.08	4.40
170	266.6	1.14	0.83	163.7	1.25	1.24	118.5	1.34	1.59	83.6	1.45	2.08	60.3	1.58	2.66	49.6	1.68	3.05	40.7	1.80	3.46	33.0	1.94	3.95	27.7	2.07	4.41
180	281.7	1.14	0.83	173.0	1.25	1.24	125.2	1.34	1.59	88.4	1.45	2.09	63.8	1.58	2.66	52.5	1.68	3.04	43.0	1.79	3.48	34.9	1.94	3.96	29.3	2.07	4.41
190	296.7	1.14	0.83	182.3	1.25	1.24	132.0	1.34	1.59	93.2	1.45	2.09	67.3	1.58	2.66	55.3	1.68	3.06	45.4	1.80	3.47	36.8	1.94	3.97	30.8	2.06	4.46
200	311.7	1.14	0.83	191.6	1.25	1.24	138.7	1.34	1.60	97.9	1.45	2.10	70.7	1.58	2.67	58.2	1.68	3.05	47.7	1.79	3.49	38.7	1.94	3.97	32.4	2.06	4.47
220	342.1	1.14	0.83	210.4	1.25	1.25	152.4	1.35	1.60	107.6	1.45	2.10	77.7	1.58	2.67	63.9	1.68	3.06	52.5	1.80	3.47	42.5	1.93	3.99	35.6	2.06	4.48
240	372.4	1.14	0.84	229.2	1.25	1.25	165.9	1.34	1.60	117.2	1.45	2.10	84.7	1.58	2.67	69.7	1.68	3.06	57.2	1.80	3.48	46.4	1.94	3.97	38.8	2.06	4.49
260	402.5	1.14	0.84	247.9	1.25	1.25	179.5	1.34	1.60	126.8	1.45	2.10	91.7	1.58	2.67	75.4	1.68	3.07	61.9	1.80	3.49	50.2	1.94	3.99	42.0	2.06	4.49
280	432.6	1.14	0.84	266.5	1.25	1.25	193.0	1.34	1.61	136.4	1.45	2.10	98.6	1.58	2.68	81.1	1.68	3.07	66.6	1.80	3.49	54.0	1.94	3.99	45.2	2.06	4.49
300	462.5	1.14	0.84	285.1	1.25	1.25	206.5	1.35	1.61	146.0	1.46	2.10	105.5	1.58	2.69	86.8	1.68	3.07	71.2	1.79	3.51	57.8	1.94	4.00	48.4	2.06	4.50

Parabolic waterway design
(Retardance "D" and "B")

4-26467 5-68

V_1 for <u>RETARDANCE "D"</u>. Top Width (T), Depth (D) and V_2 for <u>RETARDANCE "B"</u>.

Grade 3.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	28.1	0.98	0.80	19.2	1.05	1.10	13.4	1.15	1.44	10.3	1.24	1.74	7.6	1.37	2.12	5.8	1.56	2.44									
20	37.4	0.98	0.80	25.6	1.05	1.10	17.8	1.14	1.46	13.7	1.23	1.76	10.0	1.33	2.22	7.6	1.50	2.59	6.8	1.58	2.74						
25	46.7	0.99	0.80	31.9	1.05	1.11	22.2	1.14	1.47	17.0	1.21	1.80	12.5	1.33	2.23	9.4	1.46	2.69	8.4	1.54	2.85	6.9	1.68	3.18			
30	55.9	0.99	0.81	38.2	1.05	1.11	26.6	1.14	1.47	20.3	1.20	1.82	14.9	1.31	2.27	11.2	1.44	2.75	9.9	1.48	3.02	8.2	1.64	3.28	6.7	1.88	3.50
35	65.0	0.99	0.81	44.4	1.04	1.12	31.0	1.14	1.47	23.7	1.21	1.81	17.3	1.30	2.30	13.0	1.43	2.80	11.5	1.47	3.07	9.5	1.62	3.36	7.7	1.82	3.68
40	74.1	0.99	0.81	50.6	1.04	1.12	35.3	1.14	1.48	27.0	1.20	1.83	19.7	1.29	2.33	14.8	1.42	2.83	13.1	1.46	3.10	10.8	1.60	3.42	8.7	1.78	3.82
45	83.2	0.99	0.81	56.8	1.04	1.13	39.7	1.14	1.48	30.3	1.20	1.84	22.1	1.29	2.34	16.6	1.41	2.85	14.7	1.45	3.12	12.1	1.59	3.46	9.7	1.75	3.92
50	92.2	0.99	0.81	63.0	1.04	1.13	44.0	1.14	1.48	33.6	1.20	1.84	24.6	1.30	2.32	18.4	1.40	2.87	16.3	1.45	3.14	13.4	1.58	3.50	10.7	1.72	4.01
55	101.1	0.99	0.82	69.1	1.04	1.13	48.3	1.14	1.49	36.9	1.20	1.84	27.0	1.30	2.34	20.2	1.40	2.88	17.9	1.45	3.15	14.7	1.57	3.53	11.7	1.70	4.09
60	110.1	0.99	0.82	75.3	1.05	1.13	52.6	1.14	1.49	40.2	1.20	1.85	29.4	1.29	2.34	22.0	1.40	2.89	19.5	1.45	3.16	16.0	1.57	3.55	12.7	1.69	4.15
65	118.9	0.99	0.82	81.4	1.05	1.13	56.9	1.14	1.49	43.4	1.20	1.86	31.8	1.29	2.35	23.8	1.40	2.90	21.1	1.45	3.16	17.3	1.57	3.56	13.8	1.70	4.11
70	127.8	0.99	0.82	87.4	1.04	1.14	61.1	1.14	1.50	46.7	1.20	1.86	34.2	1.29	2.35	25.6	1.40	2.90	22.7	1.45	3.17	18.5	1.55	3.63	14.8	1.69	4.16
75	136.6	0.99	0.82	93.5	1.05	1.14	65.4	1.14	1.50	49.9	1.20	1.87	36.6	1.29	2.35	27.4	1.40	2.91	24.2	1.44	3.21	19.8	1.55	3.64	15.8	1.68	4.20
80	145.3	0.99	0.83	99.5	1.05	1.14	69.6	1.14	1.50	53.1	1.20	1.87	38.9	1.29	2.37	29.2	1.40	2.91	25.8	1.44	3.21	21.1	1.55	3.64	16.9	1.69	4.16
90	163.1	0.99	0.83	111.7	1.05	1.14	78.2	1.14	1.50	59.7	1.20	1.87	43.7	1.29	2.38	32.7	1.39	2.94	29.0	1.44	3.21	23.7	1.54	3.66	18.9	1.67	4.23
100	180.8	0.99	0.83	123.8	1.05	1.15	86.7	1.14	1.51	66.2	1.20	1.88	48.5	1.29	2.38	36.3	1.39	2.95	32.2	1.44	3.21	26.3	1.54	3.67	21.0	1.67	4.23
110	198.3	0.99	0.83	135.9	1.05	1.15	95.2	1.14	1.51	72.7	1.20	1.88	53.3	1.29	2.38	39.9	1.39	2.95	35.4	1.44	3.21	28.9	1.54	3.67	23.1	1.68	4.22
120	215.8	0.99	0.83	148.0	1.05	1.15	103.7	1.14	1.51	79.2	1.20	1.88	58.1	1.29	2.38	43.5	1.39	2.95	38.5	1.43	3.23	31.5	1.54	3.68	25.1	1.67	4.27
130	233.3	0.99	0.83	160.0	1.05	1.15	112.1	1.14	1.51	85.7	1.20	1.88	62.8	1.29	2.39	47.0	1.39	2.96	41.7	1.44	3.23	34.1	1.54	3.68	27.2	1.67	4.26
140	250.6	0.99	0.84	171.9	1.05	1.15	120.5	1.14	1.52	92.1	1.20	1.89	67.6	1.29	2.38	50.6	1.39	2.96	44.8	1.43	3.24	36.7	1.54	3.68	29.3	1.67	4.25
150	267.8	0.99	0.84	183.8	1.05	1.16	128.9	1.14	1.52	98.5	1.20	1.89	72.3	1.29	2.39	54.1	1.39	2.97	48.0	1.44	3.24	39.3	1.55	3.68	31.3	1.67	4.28
160	285.0	0.99	0.84	195.7	1.05	1.16	137.2	1.14	1.52	104.9	1.20	1.89	77.0	1.29	2.39	57.7	1.39	2.96	51.1	1.44	3.25	41.8	1.54	3.70	33.4	1.67	4.27
170	302.0	0.99	0.84	207.5	1.05	1.16	145.5	1.14	1.52	111.3	1.20	1.89	81.7	1.29	2.40	61.2	1.39	2.97	54.3	1.44	3.24	44.4	1.54	3.70	35.4	1.67	4.29
180	319.0	0.99	0.84	219.2	1.05	1.16	153.8	1.14	1.53	117.7	1.20	1.89	86.4	1.29	2.40	64.7	1.39	2.98	57.4	1.44	3.25	47.0	1.55	3.69	37.5	1.67	4.28
190	335.9	0.99	0.85	231.0	1.05	1.16	162.1	1.14	1.53	124.0	1.20	1.90	91.1	1.30	2.40	68.2	1.39	2.98	60.5	1.44	3.25	49.5	1.54	3.71	39.5	1.67	4.30
200	352.7	0.99	0.85	242.6	1.05	1.16	170.3	1.14	1.53	130.3	1.20	1.90	95.7	1.29	2.40	71.7	1.39	2.99	63.6	1.44	3.26	52.1	1.55	3.70	41.6	1.67	4.28
220	387.1	0.99	0.85	266.3	1.05	1.17	187.0	1.14	1.53	143.1	1.20	1.90	105.1	1.29	2.41	78.8	1.39	2.99	69.9	1.44	3.26	57.2	1.54	3.71	45.7	1.67	4.29
240	421.2	0.99	0.85	289.9	1.05	1.17	203.6	1.14	1.53	155.9	1.20	1.90	114.5	1.29	2.41	85.9	1.39	2.99	76.2	1.44	3.26	62.3	1.54	3.72	49.8	1.67	4.30
260	455.2	0.99	0.85	313.4	1.05	1.17	220.2	1.14	1.54	168.6	1.20	1.91	123.9	1.30	2.41	92.9	1.39	2.99	82.4	1.44	3.27	67.5	1.55	3.72	53.9	1.67	4.31
280	489.0	0.99	0.85	336.9	1.05	1.17	236.7	1.14	1.54	181.3	1.20	1.91	133.3	1.30	2.41	99.9	1.39	3.00	88.6	1.44	3.27	72.6	1.55	3.72	58.0	1.67	4.31
300	522.6	0.99	0.86	360.2	1.05	1.17	253.2	1.15	1.54	193.9	1.20	1.91	142.6	1.30	2.42	106.9	1.39	3.00	94.9	1.44	3.27	77.7	1.55	3.73	62.0	1.67	4.33

Parabolic waterway design
(Retardance "D" and "B")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 4.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	33.1	0.87	0.77	23.6	0.93	1.01	16.3	1.00	1.36	12.1	1.08	1.69	9.2	1.15	2.08
20	44.0	0.87	0.77	31.4	0.93	1.01	21.7	1.00	1.37	16.1	1.08	1.70	12.3	1.16	2.08
25	54.9	0.87	0.77	39.1	0.93	1.02	27.1	1.00	1.37	20.1	1.08	1.71	15.3	1.15	2.11
30	65.7	0.87	0.78	46.8	0.93	1.02	32.4	0.99	1.38	24.0	1.07	1.73	18.3	1.14	2.13
35	76.4	0.87	0.78	54.5	0.93	1.02	37.7	0.99	1.39	27.9	1.07	1.74	21.3	1.14	2.14
40	87.1	0.87	0.78	62.1	0.93	1.03	43.0	0.99	1.39	31.9	1.07	1.74	24.3	1.14	2.15
45	97.7	0.87	0.78	69.7	0.93	1.03	48.3	0.99	1.39	35.8	1.07	1.74	27.2	1.13	2.17
50	108.3	0.87	0.78	77.3	0.93	1.03	53.5	0.99	1.40	39.7	1.07	1.75	30.2	1.13	2.17
55	118.8	0.87	0.78	84.7	0.93	1.04	58.7	0.99	1.40	43.6	1.07	1.75	33.2	1.13	2.17
60	129.2	0.87	0.79	92.2	0.93	1.04	63.9	0.99	1.40	47.4	1.07	1.76	36.1	1.13	2.18
65	139.6	0.87	0.79	99.6	0.93	1.04	69.1	0.99	1.41	51.3	1.07	1.76	39.0	1.13	2.19
70	149.9	0.88	0.79	107.0	0.93	1.04	74.2	0.99	1.41	55.1	1.07	1.77	42.0	1.13	2.19
75	160.2	0.88	0.79	114.3	0.93	1.05	79.3	0.99	1.42	58.9	1.07	1.77	44.9	1.13	2.19
80	170.4	0.88	0.79	121.6	0.93	1.05	84.4	0.99	1.42	62.7	1.07	1.77	47.8	1.13	2.20
90	191.1	0.88	0.80	136.5	0.93	1.05	94.8	0.99	1.42	70.4	1.07	1.78	53.7	1.13	2.20
100	211.8	0.88	0.80	151.2	0.93	1.05	105.1	0.99	1.42	78.1	1.07	1.78	59.6	1.13	2.20
110	232.3	0.88	0.80	165.9	0.93	1.06	115.3	0.99	1.43	85.8	1.07	1.78	65.4	1.13	2.21
120	252.7	0.88	0.80	180.5	0.93	1.06	125.5	0.99	1.43	93.4	1.07	1.78	71.2	1.13	2.22
130	273.0	0.88	0.80	195.1	0.93	1.06	135.6	0.99	1.43	101.0	1.07	1.79	77.0	1.13	2.22
140	293.2	0.88	0.80	209.5	0.93	1.06	145.7	0.99	1.44	108.5	1.07	1.79	82.8	1.13	2.22
150	313.3	0.88	0.81	223.9	0.93	1.07	155.8	0.99	1.44	116.0	1.07	1.80	88.6	1.13	2.22
160	333.2	0.88	0.81	238.2	0.93	1.07	165.8	1.00	1.44	123.5	1.07	1.80	94.3	1.13	2.23
170	353.1	0.88	0.81	252.4	0.93	1.07	175.8	1.00	1.44	131.0	1.07	1.80	100.0	1.13	2.23
180	372.8	0.88	0.81	266.5	0.93	1.07	185.7	1.00	1.45	138.4	1.07	1.80	105.7	1.13	2.24
190	392.4	0.88	0.81	280.6	0.93	1.08	195.6	1.00	1.45	145.8	1.07	1.81	111.4	1.13	2.24
200	411.9	0.88	0.82	294.6	0.93	1.08	205.4	1.00	1.45	153.2	1.07	1.81	117.1	1.14	2.24
220	451.9	0.88	0.82	323.2	0.93	1.08	225.4	1.00	1.46	168.2	1.07	1.81	128.6	1.14	2.24
240	491.6	0.88	0.82	351.6	0.93	1.09	245.3	1.00	1.46	183.2	1.07	1.81	140.0	1.14	2.25
260	531.0	0.88	0.82	379.9	0.93	1.09	265.2	1.00	1.46	198.0	1.07	1.82	151.5	1.14	2.25
280	570.3	0.88	0.82	408.0	0.93	1.09	284.9	1.00	1.47	212.9	1.08	1.82	162.8	1.14	2.25
300	609.3	0.88	0.83	436.0	0.93	1.09	304.6	1.00	1.47	227.6	1.08	1.83	174.2	1.14	2.25

Q cfs	V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	7.4	1.27	2.34	5.7	1.43	2.69						
20	9.7	1.23	2.48	7.4	1.35	2.94	6.4	1.47	3.12			
25	12.1	1.22	2.50	9.2	1.33	3.01	7.9	1.43	3.26	6.5	1.56	3.62
30	14.4	1.20	2.57	11.0	1.32	3.05	9.3	1.38	3.46	7.7	1.52	3.78
35	16.8	1.20	2.57	12.7	1.30	3.14	10.9	1.39	3.42	8.9	1.49	3.90
40	19.2	1.21	2.56	14.5	1.30	3.15	12.4	1.38	3.47	10.2	1.50	3.87
45	21.5	1.20	2.59	16.3	1.30	3.16	13.9	1.37	3.51	11.4	1.48	3.95
50	23.9	1.20	2.58	18.1	1.30	3.16	15.4	1.36	3.54	12.6	1.46	4.01
55	26.2	1.20	2.60	19.8	1.29	3.21	16.9	1.36	3.56	13.8	1.45	4.06
60	28.5	1.19	2.62	21.6	1.29	3.20	18.4	1.36	3.57	15.1	1.46	4.02
65	30.9	1.20	2.61	23.4	1.29	3.19	19.9	1.35	3.58	16.3	1.46	4.06
70	33.2	1.20	2.62	25.1	1.28	3.23	21.4	1.35	3.59	17.5	1.45	4.09
75	35.5	1.20	2.62	26.9	1.29	3.22	22.9	1.35	3.60	18.7	1.45	4.12
80	37.8	1.20	2.63	28.6	1.28	3.24	24.4	1.35	3.60	20.0	1.46	4.08
90	42.4	1.19	2.65	32.1	1.28	3.26	27.4	1.35	3.62	22.4	1.45	4.13
100	47.1	1.20	2.64	35.7	1.29	3.24	30.4	1.35	3.63	24.9	1.45	4.12
110	51.7	1.19	2.65	39.2	1.29	3.25	33.4	1.35	3.63	27.3	1.44	4.16
120	56.3	1.19	2.66	42.7	1.28	3.26	36.3	1.34	3.66	29.8	1.45	4.14
130	60.9	1.19	2.66	46.2	1.29	3.26	39.3	1.34	3.66	32.2	1.44	4.16
140	65.5	1.20	2.66	49.6	1.28	3.28	42.3	1.35	3.66	34.6	1.44	4.18
150	70.1	1.20	2.66	53.1	1.28	3.28	45.3	1.35	3.66	37.1	1.45	4.17
160	74.6	1.20	2.67	56.6	1.28	3.28	48.2	1.35	3.67	39.5	1.44	4.18
170	79.2	1.20	2.67	60.0	1.28	3.29	51.2	1.35	3.67	41.9	1.44	4.19
180	83.7	1.20	2.68	63.5	1.28	3.29	54.1	1.35	3.68	44.3	1.44	4.20
190	88.2	1.20	2.68	66.9	1.28	3.30	57.0	1.34	3.69	46.7	1.44	4.21
200	92.7	1.20	2.68	70.3	1.28	3.30	60.0	1.35	3.68	49.1	1.44	4.21
220	101.9	1.20	2.68	77.2	1.28	3.31	65.9	1.35	3.69	54.0	1.44	4.21
240	110.9	1.20	2.69	84.1	1.28	3.32	71.8	1.35	3.70	58.8	1.44	4.22
260	120.0	1.20	2.69	91.0	1.28	3.32	77.7	1.35	3.70	63.7	1.44	4.21
280	129.0	1.20	2.70	97.9	1.28	3.32	83.5	1.35	3.71	68.5	1.44	4.22
300	138.1	1.20	2.69	104.8	1.29	3.32	89.4	1.35	3.71	73.3	1.44	4.23

Parabolic waterway design
(Retardance "D" and "B")

4-26467 5-58

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 5.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	34.8	0.80	0.79	25.2	0.86	1.02	17.7	0.92	1.36	14.3	0.96	1.61	10.6	1.04	2.00	8.4	1.12	2.34	6.7	1.23	2.67	5.4	1.36	3.00			
20	46.3	0.80	0.79	33.5	0.86	1.02	23.5	0.92	1.37	19.0	0.96	1.62	14.1	1.04	2.02	11.1	1.10	2.41	8.8	1.19	2.81	7.0	1.28	3.29	6.1	1.40	3.44
25	57.7	0.80	0.80	41.7	0.86	1.03	29.3	0.92	1.38	23.7	0.96	1.63	17.5	1.03	2.06	13.8	1.09	2.46	10.9	1.17	2.90	8.7	1.26	3.37	7.5	1.35	3.64
30	69.0	0.80	0.80	49.9	0.86	1.04	35.0	0.91	1.39	28.3	0.95	1.65	21.0	1.03	2.06	16.6	1.10	2.44	13.0	1.15	2.96	10.4	1.25	3.41	8.9	1.32	3.78
35	80.3	0.80	0.80	58.1	0.86	1.04	40.8	0.91	1.39	33.0	0.95	1.65	24.4	1.02	2.08	19.3	1.09	2.46	15.2	1.16	2.94	12.1	1.24	3.45	10.3	1.30	3.87
40	91.5	0.81	0.80	66.2	0.86	1.04	46.5	0.91	1.40	37.6	0.95	1.66	27.8	1.02	2.09	22.0	1.09	2.47	17.3	1.15	2.97	13.8	1.24	3.47	11.8	1.30	3.85
45	102.6	0.81	0.81	74.2	0.86	1.05	52.2	0.91	1.40	42.2	0.95	1.66	31.3	1.03	2.08	24.7	1.09	2.48	19.4	1.15	2.99	15.4	1.22	3.55	13.2	1.29	3.91
50	113.7	0.81	0.81	82.3	0.86	1.05	57.9	0.92	1.40	46.8	0.95	1.66	34.7	1.03	2.08	27.3	1.08	2.51	21.5	1.15	3.01	17.1	1.22	3.55	14.7	1.30	3.88
55	124.7	0.81	0.81	90.2	0.86	1.05	63.5	0.91	1.41	51.4	0.96	1.66	38.0	1.02	2.11	30.0	1.08	2.51	23.7	1.15	2.98	18.8	1.22	3.55	16.1	1.29	3.93
60	135.7	0.81	0.81	98.2	0.86	1.05	69.1	0.91	1.41	56.0	0.96	1.66	41.4	1.02	2.11	32.7	1.08	2.51	25.8	1.15	3.00	20.5	1.22	3.55	17.5	1.28	3.97
65	146.5	0.81	0.81	106.1	0.86	1.05	74.7	0.92	1.41	60.5	0.96	1.67	44.8	1.02	2.10	35.3	1.08	2.53	27.9	1.15	3.00	22.1	1.22	3.59	18.9	1.28	4.00
70	157.3	0.81	0.82	113.9	0.86	1.06	80.2	0.91	1.42	65.0	0.96	1.67	48.1	1.02	2.11	38.0	1.08	2.53	30.0	1.15	3.01	23.8	1.22	3.58	20.4	1.29	3.96
75	168.1	0.81	0.82	121.7	0.86	1.06	85.8	0.92	1.42	69.5	0.96	1.67	51.4	1.02	2.12	40.6	1.08	2.54	32.0	1.15	3.04	25.4	1.21	3.62	21.8	1.28	3.98
80	178.8	0.81	0.82	129.4	0.86	1.06	91.3	0.92	1.42	74.0	0.96	1.67	54.8	1.02	2.12	43.3	1.09	2.53	34.1	1.15	3.04	27.1	1.22	3.61	23.2	1.28	4.00
90	200.5	0.81	0.82	145.2	0.86	1.07	102.4	0.92	1.43	83.0	0.96	1.68	61.5	1.02	2.12	48.6	1.08	2.54	38.3	1.15	3.05	30.4	1.21	3.63	26.1	1.28	4.00
100	222.2	0.81	0.82	160.9	0.86	1.07	113.5	0.92	1.43	92.1	0.96	1.68	68.2	1.02	2.13	53.9	1.08	2.54	42.5	1.15	3.05	33.8	1.22	3.61	28.9	1.28	4.03
110	243.7	0.81	0.82	176.5	0.86	1.07	124.6	0.92	1.43	101.0	0.96	1.69	74.8	1.02	2.14	59.2	1.09	2.55	46.7	1.15	3.05	37.1	1.22	3.63	31.8	1.28	4.02
120	265.0	0.81	0.83	192.0	0.86	1.07	135.6	0.92	1.43	110.0	0.96	1.69	81.4	1.02	2.15	64.4	1.08	2.56	50.8	1.15	3.07	40.4	1.21	3.64	34.6	1.28	4.04
130	286.3	0.81	0.83	207.5	0.86	1.08	146.6	0.92	1.43	118.9	0.96	1.69	88.1	1.02	2.14	69.7	1.09	2.56	55.0	1.15	3.06	43.7	1.21	3.65	37.5	1.28	4.03
140	307.4	0.81	0.83	222.8	0.86	1.08	157.5	0.92	1.44	127.8	0.96	1.69	94.6	1.02	2.15	74.9	1.08	2.57	59.1	1.15	3.07	47.0	1.21	3.65	40.3	1.28	4.04
150	328.4	0.81	0.83	238.1	0.87	1.08	168.3	0.92	1.44	136.6	0.96	1.70	101.2	1.02	2.15	80.1	1.08	2.57	63.2	1.15	3.08	50.2	1.21	3.67	43.1	1.28	4.05
160	349.3	0.81	0.83	253.2	0.86	1.08	179.1	0.92	1.44	145.4	0.96	1.70	107.7	1.02	2.16	85.3	1.09	2.57	67.3	1.15	3.09	53.5	1.21	3.67	45.9	1.28	4.06
170	370.0	0.81	0.84	268.3	0.87	1.09	189.9	0.92	1.45	154.1	0.96	1.70	114.2	1.02	2.16	90.4	1.08	2.58	71.4	1.15	3.09	56.8	1.21	3.67	48.7	1.28	4.07
180	390.7	0.82	0.84	283.3	0.87	1.09	200.6	0.92	1.45	162.9	0.96	1.70	120.7	1.02	2.17	95.6	1.09	2.58	75.5	1.15	3.09	60.0	1.21	3.69	51.5	1.28	4.07
190	411.2	0.82	0.84	298.2	0.87	1.09	211.2	0.92	1.45	171.5	0.96	1.71	127.1	1.02	2.17	100.7	1.08	2.59	79.6	1.15	3.09	63.3	1.21	3.68	54.3	1.28	4.07
200	431.6	0.82	0.84	313.0	0.87	1.09	221.8	0.92	1.46	180.2	0.96	1.71	133.5	1.02	2.18	105.8	1.09	2.59	83.6	1.15	3.10	66.5	1.21	3.69	57.1	1.28	4.08
220	473.3	0.82	0.84	343.4	0.87	1.10	243.4	0.92	1.46	197.8	0.97	1.71	146.6	1.02	2.18	116.2	1.09	2.60	91.9	1.15	3.10	73.1	1.22	3.69	62.7	1.28	4.09
240	514.8	0.82	0.84	373.6	0.87	1.10	264.9	0.92	1.46	215.3	0.97	1.72	159.6	1.02	2.18	126.5	1.09	2.60	100.1	1.15	3.10	79.6	1.21	3.70	68.3	1.28	4.09
260	556.1	0.82	0.85	403.6	0.87	1.10	286.3	0.92	1.46	232.7	0.97	1.72	172.6	1.03	2.19	136.8	1.09	2.61	108.2	1.15	3.11	86.1	1.21	3.71	73.9	1.28	4.10
280	597.1	0.82	0.85	433.5	0.87	1.10	307.6	0.92	1.47	250.1	0.97	1.72	185.5	1.03	2.19	147.1	1.09	2.61	116.4	1.15	3.11	92.6	1.21	3.71	79.5	1.28	4.10
300	638.0	0.82	0.85	463.1	0.87	1.11	328.7	0.92	1.47	267.4	0.97	1.73	198.4	1.03	2.19	157.3	1.09	2.61	124.5	1.15	3.12	99.1	1.22	3.71	85.1	1.28	4.10

Parabolic waterway design
(Retardance "D" and "B")

4-26467 5-68

V_1 for <u>RETARDANCE "D"</u>. Top Width (T), Depth (D) and V_2 for <u>RETARDANCE "B"</u>.

Grade 6.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	40.5	0.72	0.76	26.9	0.81	1.02	19.6	0.85	1.34	14.8	0.90	1.66	11.7	0.96	1.97	9.4	1.02	2.31	7.6	1.09	2.67	6.1	1.18	3.05	5.0	1.32	3.33
20	53.9	0.72	0.76	35.7	0.81	1.03	26.1	0.85	1.34	19.6	0.89	1.69	15.6	0.96	1.97	12.5	1.01	2.33	10.1	1.08	2.71	8.0	1.14	3.23	6.5	1.24	3.63
25	67.1	0.72	0.76	44.5	0.81	1.03	32.5	0.85	1.35	24.5	0.90	1.69	19.4	0.95	2.00	15.5	1.00	2.39	12.5	1.06	2.80	10.0	1.14	3.24	8.1	1.23	3.69
30	80.3	0.72	0.76	53.2	0.80	1.04	38.9	0.85	1.35	29.3	0.89	1.70	23.3	0.96	1.99	18.6	1.00	2.39	15.0	1.06	2.80	11.9	1.12	3.32	9.6	1.20	3.84
35	93.4	0.72	0.76	61.9	0.81	1.04	45.3	0.85	1.35	34.1	0.89	1.70	27.1	0.96	2.00	21.6	0.99	2.42	17.4	1.05	2.84	13.9	1.13	3.31	11.2	1.20	3.84
40	106.4	0.73	0.77	70.6	0.81	1.04	51.6	0.85	1.36	38.9	0.89	1.71	30.9	0.95	2.01	24.7	1.00	2.41	19.9	1.05	2.83	15.8	1.12	3.36	12.7	1.19	3.93
45	119.3	0.73	0.77	79.2	0.81	1.04	57.9	0.85	1.36	43.7	0.90	1.71	34.6	0.95	2.03	27.7	1.00	2.42	22.3	1.05	2.86	17.7	1.11	3.40	14.3	1.19	3.92
50	132.1	0.73	0.77	87.7	0.81	1.05	64.1	0.84	1.37	48.4	0.89	1.71	38.4	0.95	2.03	30.7	0.99	2.43	24.7	1.05	2.87	19.7	1.12	3.38	15.8	1.18	3.98
55	144.9	0.73	0.77	96.2	0.81	1.05	70.4	0.85	1.37	53.1	0.89	1.72	42.2	0.95	2.03	33.7	0.99	2.44	27.1	1.04	2.89	21.6	1.11	3.40	17.4	1.18	3.96
60	157.5	0.73	0.77	104.6	0.81	1.05	76.5	0.84	1.38	57.8	0.89	1.72	45.9	0.95	2.04	36.7	1.00	2.44	29.6	1.05	2.87	23.5	1.11	3.42	18.9	1.18	4.01
65	170.1	0.73	0.78	113.0	0.81	1.06	82.7	0.85	1.38	62.5	0.90	1.72	49.6	0.95	2.04	39.7	1.00	2.44	32.0	1.05	2.88	25.4	1.11	3.43	20.5	1.18	3.98
70	182.6	0.73	0.78	121.3	0.81	1.06	88.8	0.85	1.38	67.2	0.90	1.72	53.3	0.95	2.05	42.7	1.00	2.44	34.4	1.05	2.88	27.4	1.11	3.41	22.0	1.18	4.01
75	195.1	0.73	0.78	129.6	0.81	1.06	94.9	0.85	1.39	71.8	0.90	1.73	57.0	0.95	2.05	45.6	1.00	2.46	36.7	1.04	2.91	29.3	1.11	3.42	23.6	1.18	3.99
80	207.4	0.73	0.78	137.8	0.81	1.06	100.9	0.85	1.39	76.4	0.90	1.73	60.6	0.95	2.06	48.6	1.00	2.45	39.1	1.05	2.91	31.2	1.11	3.42	25.1	1.18	4.02
90	232.6	0.73	0.78	154.5	1.81	1.07	113.2	0.85	1.40	85.8	0.90	1.73	68.1	0.95	2.06	54.6	1.00	2.45	43.9	1.05	2.92	35.0	1.11	3.44	28.2	1.18	4.02
100	257.7	0.73	0.78	171.2	0.81	1.07	125.5	0.85	1.40	95.1	0.90	1.74	75.5	0.95	2.06	60.5	1.00	2.46	48.7	1.05	2.92	38.8	1.11	3.46	31.3	1.18	4.03
110	282.6	0.74	0.78	187.8	0.81	1.07	137.7	0.85	1.40	104.4	0.90	1.74	82.8	0.95	2.07	66.4	1.00	2.47	53.5	1.05	2.92	42.6	1.11	3.47	34.4	1.18	4.03
120	307.3	0.74	0.79	204.2	0.81	1.08	149.8	0.85	1.40	113.6	0.90	1.74	90.2	0.95	2.07	72.3	1.00	2.47	58.3	1.05	2.92	46.4	1.11	3.47	37.4	1.18	4.06
130	331.9	0.74	0.79	220.6	0.81	1.08	161.9	0.85	1.41	122.8	0.90	1.75	97.5	0.95	2.08	78.2	1.00	2.48	63.0	1.05	2.93	50.2	1.11	3.48	40.5	1.18	4.05
140	356.3	0.74	0.79	236.8	0.81	1.08	173.9	0.85	1.41	131.9	0.90	1.75	104.7	0.95	2.09	84.0	1.00	2.48	67.7	1.05	2.94	54.0	1.11	3.48	43.5	1.18	4.07
150	380.5	0.74	0.79	253.0	0.81	1.09	185.8	0.85	1.41	141.0	0.90	1.75	112.0	0.96	2.09	89.9	1.00	2.48	72.5	1.05	2.93	57.8	1.11	3.48	46.6	1.18	4.06
160	404.6	0.74	0.79	269.0	0.81	1.09	197.7	0.85	1.42	150.1	0.90	1.76	119.2	0.96	2.09	95.7	1.00	2.49	77.2	1.05	2.94	61.5	1.11	3.49	49.6	1.18	4.08
170	428.6	0.74	0.79	285.0	0.81	1.09	209.5	0.85	1.42	159.1	0.90	1.76	126.4	0.96	2.09	101.5	1.00	2.49	81.8	1.05	2.95	65.3	1.11	3.49	52.7	1.18	4.07
180	452.4	0.74	0.79	300.8	0.81	1.09	221.3	0.85	1.42	168.1	0.90	1.76	133.5	0.96	2.10	107.2	1.00	2.50	86.5	1.05	2.95	69.0	1.11	3.49	55.7	1.18	4.08
190	476.1	0.74	0.80	316.6	0.81	1.10	233.0	0.85	1.42	177.0	0.90	1.77	140.6	0.96	2.10	113.0	1.00	2.50	91.1	1.05	2.96	72.7	1.11	3.50	58.7	1.13	4.08
200	499.6	0.74	0.80	332.3	0.81	1.10	244.6	0.85	1.43	185.9	0.90	1.77	147.7	0.96	2.11	118.7	1.00	2.50	95.8	1.05	2.96	76.4	1.11	3.51	61.7	1.18	4.09
220	547.7	0.74	0.80	364.5	0.81	1.10	268.4	0.85	1.43	204.1	0.91	1.77	162.1	0.96	2.11	130.3	1.00	2.51	105.2	1.05	2.96	83.9	1.11	3.51	67.8	1.18	4.09
240	595.6	0.74	0.80	396.5	0.81	1.11	292.1	0.85	1.43	222.1	0.91	1.78	176.5	0.96	2.11	141.9	1.00	2.51	114.5	1.05	2.97	91.4	1.11	3.52	73.8	1.18	4.11
260	643.2	0.74	0.80	428.3	0.81	1.11	315.7	0.85	1.43	240.1	0.91	1.78	190.7	0.96	2.12	153.4	1.00	2.52	123.9	1.05	2.97	98.9	1.11	3.52	79.9	1.18	4.10
280	690.5	0.75	0.81	459.9	0.81	1.11	339.1	0.85	1.44	258.0	0.91	1.78	205.0	0.96	2.12	164.9	1.00	2.52	133.2	1.05	2.97	106.3	1.11	3.53	85.9	1.18	4.11
300	737.5	0.75	0.81	491.4	0.81	1.11	362.4	0.85	1.44	275.8	0.91	1.78	219.1	0.96	2.13	176.3	1.00	2.52	142.4	1.05	2.98	113.7	1.11	3.53	91.9	1.18	4.12

Parabolic waterway design
(Retardance "D" and "B")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 8.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	43.1	0.64	0.80	31.6	0.71	0.98	22.2	0.76	1.31	18.0	0.79	1.56	13.7	0.84	1.92	11.0	0.89	2.26	9.2	0.95	2.54	7.4	0.99	3.00	6.2	1.09	3.26
20	57.3	0.64	0.80	42.0	0.71	0.99	29.5	0.76	1.32	24.0	0.79	1.56	18.2	0.84	1.94	14.7	0.89	2.25	12.2	0.93	2.59	9.8	0.98	3.08	8.1	1.04	3.49
25	71.4	0.65	0.80	52.3	0.71	0.99	36.7	0.76	1.33	29.9	0.79	1.57	22.7	0.84	1.95	18.3	0.89	2.28	15.2	0.93	2.62	12.2	0.97	3.12	10.1	1.04	3.53
30	85.4	0.65	0.80	62.6	0.71	0.99	43.9	0.76	1.33	35.8	0.79	1.57	27.2	0.84	1.95	21.9	0.89	2.29	18.1	0.92	2.67	14.6	0.97	3.15	12.1	1.03	3.55
35	99.3	0.65	0.80	72.8	0.72	0.99	51.1	0.76	1.34	41.6	0.79	1.58	31.7	0.84	1.95	25.5	0.89	2.30	21.1	0.92	2.67	17.0	0.96	3.16	14.0	1.02	3.64
40	113.1	0.65	0.81	82.9	0.72	1.00	58.2	0.76	1.34	47.4	0.79	1.59	36.1	0.84	1.96	29.0	0.88	2.32	24.1	0.92	2.67	19.4	0.96	3.17	16.0	1.02	3.63
45	126.8	0.65	0.81	93.0	0.72	1.00	65.3	0.76	1.34	53.2	0.79	1.59	40.5	0.84	1.97	32.6	0.88	2.32	27.0	0.92	2.69	21.8	0.97	3.17	18.0	1.02	3.62
50	140.4	0.65	0.81	102.9	0.72	1.01	72.3	0.76	1.35	59.0	0.79	1.59	44.9	0.84	1.97	36.1	0.88	2.33	30.0	0.92	2.68	24.2	0.97	3.17	19.9	1.02	3.67
55	153.9	0.65	0.81	112.8	0.72	1.01	79.3	0.76	1.35	64.7	0.79	1.60	49.3	0.84	1.97	39.6	0.88	2.34	32.9	0.92	2.70	26.5	0.96	3.20	21.9	1.02	3.65
60	167.3	0.65	0.81	122.7	0.72	1.01	86.2	0.76	1.36	70.4	0.79	1.60	53.7	0.84	1.97	43.1	0.88	2.34	35.8	0.92	2.70	28.9	0.97	3.19	23.8	1.02	3.69
65	180.6	0.65	0.82	132.4	0.72	1.01	93.1	0.76	1.36	76.0	0.79	1.61	58.0	0.84	1.98	46.6	0.88	2.35	38.7	0.92	2.71	31.3	0.97	3.18	25.7	1.01	3.71
70	193.9	0.65	0.82	142.2	0.72	1.01	100.0	0.76	1.37	81.7	0.79	1.61	62.3	0.84	1.98	50.1	0.88	2.35	41.6	0.92	2.71	33.6	0.97	3.20	27.7	1.02	3.69
75	207.0	0.65	0.82	151.8	0.72	1.02	106.8	0.76	1.37	87.2	0.79	1.62	66.6	0.84	1.99	53.5	0.88	2.36	44.5	0.92	2.72	35.9	0.96	3.22	29.6	1.02	3.71
80	220.1	0.66	0.82	161.4	0.72	1.02	113.6	0.76	1.37	92.8	0.79	1.62	70.9	0.84	1.99	56.9	0.88	2.37	47.3	0.92	2.73	38.2	0.96	3.23	31.5	1.01	3.72
90	246.8	0.66	0.82	180.9	0.72	1.02	127.4	0.76	1.38	104.1	0.79	1.62	79.5	0.84	2.00	63.9	0.88	2.37	53.1	0.92	2.74	42.9	0.96	3.23	35.4	1.02	3.72
100	273.3	0.66	0.82	200.3	0.72	1.03	141.1	0.76	1.38	115.4	0.79	1.62	88.1	0.84	2.00	70.8	0.88	2.38	58.9	0.92	2.74	47.6	0.97	3.24	39.2	1.01	3.75
110	299.6	0.66	0.83	219.6	0.72	1.03	154.8	0.76	1.38	126.5	0.79	1.63	96.7	0.84	2.01	77.7	0.88	2.38	64.7	0.92	2.74	52.3	0.97	3.23	43.1	1.02	3.74
120	325.7	0.66	0.83	238.8	0.72	1.03	168.4	0.76	1.39	137.7	0.79	1.63	105.3	0.84	2.01	84.6	0.88	2.39	70.4	0.92	2.75	56.9	0.97	3.25	46.9	1.01	3.75
130	351.7	0.66	0.83	257.9	0.72	1.04	181.9	0.76	1.39	148.7	0.79	1.64	113.8	0.84	2.01	91.4	0.88	2.40	76.1	0.92	2.75	61.6	0.97	3.24	50.7	1.01	3.76
140	377.5	0.66	0.83	276.8	0.72	1.04	195.3	0.76	1.39	159.7	0.79	1.64	122.2	0.84	2.02	98.2	0.88	2.40	81.8	0.92	2.76	66.2	0.97	3.25	54.5	1.01	3.77
150	403.1	0.66	0.83	295.6	0.72	1.04	208.6	0.76	1.40	170.7	0.80	1.64	130.6	0.84	2.02	105.0	0.88	2.40	87.4	0.92	2.77	70.8	0.97	3.25	58.3	1.01	3.78
160	428.5	0.66	0.83	314.2	0.72	1.04	221.9	0.76	1.40	181.5	0.79	1.65	139.0	0.85	2.02	111.7	0.88	2.41	93.1	0.92	2.77	75.3	0.97	3.27	62.1	1.01	3.78
170	453.8	0.66	0.84	332.8	0.72	1.05	235.1	0.76	1.40	192.4	0.80	1.65	147.3	0.85	2.03	118.4	0.88	2.42	98.7	0.92	2.77	79.9	0.97	3.27	65.9	1.02	3.78
180	478.9	0.66	0.84	351.2	0.72	1.05	248.2	0.76	1.41	203.1	0.80	1.65	155.6	0.85	2.03	125.1	0.88	2.42	104.3	0.93	2.78	84.4	0.97	3.28	69.6	1.02	3.79
190	503.9	0.66	0.84	369.5	0.72	1.05	261.2	0.77	1.41	213.8	0.80	1.66	163.9	0.85	2.03	131.8	0.89	2.42	109.8	0.92	2.79	89.0	0.97	3.27	73.4	1.02	3.79
200	528.5	0.67	0.84	387.7	0.73	1.05	274.1	0.77	1.42	224.4	0.80	1.66	172.1	0.85	2.04	138.4	0.89	2.43	115.3	0.92	2.79	93.5	0.97	3.28	77.1	1.02	3.80
220	579.5	0.67	0.84	425.1	0.73	1.06	300.7	0.77	1.42	246.2	0.80	1.66	188.8	0.85	2.04	151.8	0.88	2.44	126.6	0.93	2.80	102.6	0.97	3.29	84.7	1.02	3.80
240	630.1	0.67	0.84	462.2	0.73	1.06	327.0	0.77	1.42	267.9	0.80	1.67	205.5	0.85	2.05	165.2	0.89	2.44	137.8	0.93	2.80	111.8	0.97	3.29	92.2	1.02	3.81
260	680.4	0.67	0.85	499.1	0.73	1.06	353.3	0.77	1.42	289.4	0.80	1.67	222.1	0.85	2.05	178.6	0.89	2.45	149.0	0.93	2.80	120.8	0.97	3.30	99.7	1.02	3.82
280	730.4	0.67	0.85	535.6	0.73	1.07	379.3	0.77	1.43	310.8	0.80	1.68	238.6	0.85	2.05	191.9	0.89	2.45	160.1	0.93	2.81	129.9	0.97	3.30	107.2	1.02	3.82
300	780.0	0.67	0.85	572.1	0.73	1.07	405.2	0.77	1.43	332.1	0.80	1.68	255.0	0.85	2.06	205.1	0.89	2.46	171.2	0.93	2.81	138.9	0.97	3.31	114.7	1.02	3.82

Parabolic waterway design
(Retardance "D" and "B")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 10.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	51.4	0.56	0.77	38.3	0.63	0.92	27.2	0.69	1.18	19.6	0.73	1.56	15.7	0.76	1.86	12.6	0.81	2.18	10.6	0.85	2.45	8.7	0.90	2.83	7.2	0.94	3.26
20	68.2	0.55	0.78	50.9	0.63	0.92	36.2	0.69	1.18	26.1	0.73	1.56	20.9	0.76	1.87	16.8	0.81	2.18	14.0	0.84	2.53	11.5	0.88	2.91	9.5	0.92	3.39
25	85.0	0.56	0.78	63.4	0.63	0.92	45.1	0.69	1.19	32.5	0.73	1.57	26.1	0.76	1.87	20.9	0.80	2.20	17.5	0.84	2.52	14.3	0.87	2.96	11.9	0.92	3.37
30	101.6	0.56	0.78	75.8	0.63	0.92	53.9	0.69	1.20	38.8	0.72	1.58	31.2	0.76	1.88	25.0	0.80	2.22	20.9	0.83	2.55	17.1	0.87	2.98	14.2	0.91	3.42
35	118.1	0.56	0.78	88.1	0.63	0.93	62.7	0.69	1.20	45.2	0.73	1.58	36.3	0.76	1.88	29.1	0.80	2.22	24.3	0.83	2.57	19.9	0.87	3.00	16.5	0.91	3.46
40	134.4	0.56	0.79	100.3	0.64	0.93	71.3	0.69	1.21	51.5	0.73	1.59	41.3	0.76	1.90	33.2	0.80	2.22	27.7	0.83	2.58	22.7	0.87	3.00	18.9	0.91	3.43
45	150.7	0.56	0.79	112.5	0.64	0.93	80.0	0.69	1.21	57.7	0.72	1.60	46.4	0.76	1.90	37.2	0.80	2.24	31.1	0.83	2.58	25.5	0.87	3.01	21.2	0.91	3.45
50	166.8	0.56	0.79	124.5	0.64	0.93	88.5	0.69	1.21	63.9	0.72	1.60	51.3	0.76	1.91	41.3	0.80	2.23	34.5	0.83	2.58	28.3	0.87	3.01	23.5	0.91	3.46
55	182.8	0.56	0.79	136.4	0.64	0.93	97.1	0.69	1.21	70.1	0.73	1.60	56.3	0.76	1.92	45.3	0.80	2.24	37.8	0.83	2.60	31.1	0.87	3.00	25.8	0.91	3.47
60	198.6	0.56	0.79	148.2	0.64	0.94	105.5	0.69	1.22	76.2	0.72	1.61	61.2	0.76	1.92	49.3	0.80	2.25	41.1	0.83	2.61	33.8	0.87	3.02	28.1	0.91	3.47
65	214.3	0.57	0.79	160.0	0.64	0.94	113.9	0.69	1.22	82.3	0.73	1.62	66.2	0.76	1.92	53.2	0.80	2.26	44.4	0.83	2.62	36.5	0.87	3.04	30.3	0.91	3.51
70	229.9	0.57	0.79	171.6	0.64	0.94	122.2	0.69	1.23	88.4	0.73	1.62	71.0	0.76	1.93	57.2	0.80	2.26	47.7	0.83	2.63	39.3	0.87	3.03	32.6	0.91	3.50
75	245.4	0.57	0.80	183.2	0.64	0.94	130.5	0.69	1.23	94.4	0.73	1.62	75.9	0.76	1.94	61.1	0.80	2.27	51.0	0.83	2.63	42.0	0.87	3.04	34.9	0.91	3.50
80	260.7	0.57	0.80	194.6	0.64	0.95	138.6	0.69	1.24	100.3	0.73	1.63	80.7	0.76	1.94	65.0	0.80	2.27	54.3	0.83	2.63	44.7	0.87	3.04	37.1	0.91	3.52
90	292.1	0.57	0.80	218.1	0.64	0.95	155.4	0.69	1.24	112.5	0.73	1.64	90.5	0.76	1.95	73.0	0.81	2.27	60.9	0.83	2.64	50.1	0.87	3.06	41.7	0.91	3.52
100	323.3	0.57	0.80	241.5	0.64	0.95	172.1	0.69	1.24	124.6	0.73	1.64	100.3	0.76	1.95	80.9	0.81	2.28	67.5	0.83	2.65	55.6	0.87	3.06	46.2	0.91	3.53
110	354.3	0.57	0.80	264.6	0.64	0.96	188.6	0.69	1.25	136.7	0.73	1.64	110.0	0.76	1.96	88.7	0.81	2.29	74.1	0.83	2.65	61.0	0.87	3.07	50.7	0.91	3.54
120	385.0	0.57	0.80	287.6	0.64	0.96	205.0	0.69	1.25	148.7	0.73	1.65	119.6	0.76	1.97	96.5	0.81	2.29	80.6	0.83	2.66	66.4	0.87	3.08	55.2	0.91	3.55
130	415.5	0.57	0.81	310.3	0.65	0.96	221.3	0.69	1.26	160.6	0.73	1.65	129.3	0.76	1.97	104.3	0.81	2.30	87.1	0.83	2.67	71.8	0.87	3.08	59.7	0.91	3.55
140	445.7	0.57	0.81	333.0	0.65	0.96	237.5	0.69	1.26	172.5	0.73	1.65	138.8	0.76	1.97	112.1	0.81	2.30	93.5	0.83	2.68	77.1	0.87	3.09	64.2	0.91	3.55
150	475.7	0.58	0.81	355.4	0.65	0.97	253.6	0.69	1.26	184.2	0.73	1.66	148.4	0.76	1.97	119.8	0.81	2.30	100.0	0.83	2.68	82.5	0.88	3.09	68.6	0.91	3.57
160	505.5	0.58	0.81	377.7	0.65	0.97	269.5	0.69	1.27	195.9	0.73	1.66	157.8	0.76	1.98	127.4	0.81	2.31	106.4	0.83	2.69	87.8	0.88	3.10	73.0	0.91	3.58
170	535.0	0.58	0.81	399.7	0.65	0.97	285.3	0.69	1.27	207.6	0.73	1.66	167.2	0.76	1.98	135.0	0.81	2.32	112.8	0.83	2.69	93.0	0.87	3.11	77.5	0.91	3.57
180	564.3	0.58	0.81	421.7	0.65	0.97	301.0	0.70	1.28	219.1	0.73	1.67	176.6	0.76	1.99	142.6	0.81	2.32	119.1	0.83	2.70	98.3	0.88	3.11	81.8	0.91	3.59
190	593.4	0.58	0.82	443.4	0.65	0.98	316.6	0.70	1.28	230.6	0.73	1.67	185.9	0.76	1.99	150.1	0.81	2.33	125.4	0.83	2.71	103.5	0.88	3.12	86.2	0.91	3.59
200	622.2	0.58	0.82	465.0	0.65	0.98	332.1	0.70	1.28	242.1	0.73	1.68	195.2	0.76	1.99	157.6	0.81	2.33	131.7	0.83	2.71	108.7	0.88	3.13	90.6	0.92	3.59
220	681.9	0.58	0.82	509.6	0.65	0.98	364.1	0.70	1.29	265.5	0.73	1.68	214.1	0.76	2.00	173.0	0.81	2.33	144.6	0.83	2.71	119.3	0.88	3.13	99.4	0.91	3.60
240	741.1	0.58	0.82	553.8	0.65	0.99	395.9	0.70	1.29	288.8	0.73	1.68	233.0	0.76	2.00	188.2	0.81	2.34	157.4	0.84	2.72	129.9	0.88	3.13	108.3	0.92	3.60
260	799.9	0.58	0.82	597.7	0.65	0.99	427.4	0.70	1.29	312.0	0.73	1.69	251.7	0.77	2.01	203.4	0.81	2.34	170.1	0.84	2.72	140.4	0.88	3.14	117.0	0.92	3.61
280	858.2	0.58	0.83	641.3	0.65	0.99	458.7	0.70	1.30	335.0	0.73	1.69	270.4	0.77	2.01	218.5	0.81	2.35	182.7	0.84	2.73	150.9	0.88	3.15	125.8	0.92	3.62
300	916.0	0.59	0.83	684.6	0.65	0.99	489.8	0.70	1.30	357.9	0.73	1.69	289.0	0.77	2.01	233.5	0.81	2.35	195.4	0.84	2.73	161.3	0.88	3.15	134.5	0.92	3.62

Parabolic waterway design
(Retardance "D" and "B")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "C".

Grade 0.25 Percent

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15																											
20																											
25	9.6	2.36	1.63																								
30	11.4	2.31	1.68																								
35	13.2	2.27	1.73																								
40	15.0	2.25	1.76	10.4	2.67	2.13																					
45	16.8	2.23	1.78	11.6	2.62	2.19																					
50	18.6	2.21	1.80	12.8	2.59	2.24																					
55	20.4	2.20	1.82	14.0	2.56	2.28																					
60	22.2	2.19	1.83	15.2	2.53	2.31																					
65	24.0	2.18	1.84	16.5	2.54	2.30																					
70	25.8	2.18	1.85	17.7	2.52	2.33	12.6	3.05	2.70																		
75	27.6	2.17	1.86	18.9	2.51	2.35	13.4	3.00	2.76																		
80	29.4	2.17	1.87	20.1	2.50	2.37	14.3	3.01	2.76																		
90	33.1	2.17	1.86	22.6	2.49	2.38	16.0	2.97	2.81																		
100	36.7	2.17	1.87	25.1	2.49	2.38	17.7	2.95	2.85																		
110	40.3	2.16	1.88	27.5	2.47	2.41	19.4	2.93	2.88																		
120	43.9	2.16	1.89	30.0	2.47	2.41	21.1	2.91	2.91	15.2	3.58	3.28															
130	47.6	2.16	1.88	32.5	2.48	2.41	22.8	2.89	2.93	16.4	3.55	3.32															
140	51.2	2.16	1.88	34.9	2.46	2.43	24.6	2.91	2.91	17.6	3.53	3.35															
150	54.8	2.16	1.89	37.4	2.47	2.42	26.3	2.90	2.93	18.8	3.51	3.39															
160	58.4	2.16	1.89	39.9	2.47	2.42	28.0	2.89	2.95	20.0	3.49	3.41															
170	62.0	2.16	1.89	42.3	2.46	2.43	29.7	2.88	2.96	21.2	3.47	3.44	16.7	4.03	3.75												
180	65.6	2.16	1.90	44.8	2.47	2.43	31.4	2.87	2.97	22.4	3.46	3.46	17.6	4.00	3.81												
190	69.2	2.16	1.90	47.2	2.46	2.44	33.1	2.87	2.98	23.6	3.45	3.48	18.5	3.97	3.85												
200	72.8	2.16	1.90	49.7	2.46	2.44	34.9	2.88	2.97	24.8	3.44	3.49	19.4	3.94	3.90												
220	80.0	2.16	1.90	54.6	2.46	2.44	38.3	2.87	2.99	27.2	3.42	3.53	21.3	3.92	3.92												
240	87.3	2.16	1.90	59.5	2.46	2.45	41.7	2.86	3.00	29.6	3.40	3.55	23.1	3.88	3.99												
260	94.5	2.16	1.90	64.5	2.46	2.44	45.2	2.86	3.00	32.1	3.41	3.54	25.0	3.87	4.01	19.5	4.57	4.34									
280	101.7	2.16	1.90	69.4	2.46	2.45	48.6	2.85	3.01	34.5	3.40	3.56	26.9	3.86	4.02	21.0	4.57	4.34									
300	108.9	2.16	1.90	74.3	2.46	2.45	52.1	2.86	3.00	36.9	3.39	3.58	28.7	3.83	4.07	22.4	4.53	4.40									

Parabolic waterway design
(Retardance "D" and "C")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "C".

Grade 0.50 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	8.6	1.63	1.58												
20	11.3	1.58	1.66												
25	14.1	1.57	1.67	9.0	1.91	2.14									
30	16.9	1.56	1.68	10.7	1.87	2.21	8.2	2.18	2.48						
35	19.6	1.55	1.71	12.4	1.85	2.26	9.4	2.10	2.62						
40	22.4	1.55	1.71	14.1	1.83	2.30	10.7	2.08	2.66						
45	25.1	1.54	1.73	15.8	1.82	2.33	11.9	2.03	2.76						
50	27.9	1.54	1.73	17.5	1.80	2.35	13.2	2.02	2.78	9.6	2.42	3.19			
55	30.7	1.54	1.72	19.2	1.80	2.37	14.5	2.02	2.79	10.5	2.39	3.25			
60	33.4	1.54	1.74	20.9	1.79	2.38	15.8	2.01	2.80	11.4	2.37	3.30			
65	36.1	1.53	1.75	22.7	1.80	2.36	17.0	1.99	2.86	12.3	2.35	3.34			
70	38.9	1.54	1.74	24.4	1.80	2.37	18.3	1.99	2.86	13.2	2.33	3.38			
75	41.6	1.54	1.75	26.1	1.79	2.38	19.6	1.99	2.86	14.1	2.32	3.41	11.2	2.71	3.66
80	44.3	1.53	1.75	27.8	1.79	2.39	20.9	1.99	2.86	15.0	2.31	3.43	11.8	2.65	3.80
90	49.8	1.53	1.75	31.2	1.78	2.41	23.5	1.99	2.87	16.9	2.31	3.42	13.3	2.65	3.78
100	55.3	1.53	1.75	34.6	1.78	2.42	26.0	1.97	2.90	18.7	2.29	3.47	14.7	2.63	3.85
110	60.8	1.54	1.75	38.1	1.78	2.41	28.6	1.97	2.90	20.5	2.28	3.50	16.1	2.60	3.90
120	66.3	1.54	1.75	41.5	1.78	2.42	31.2	1.98	2.90	22.4	2.29	3.49	17.5	2.58	3.94
130	71.7	1.53	1.76	44.9	1.78	2.42	33.7	1.97	2.92	24.2	2.28	3.51	18.9	2.57	3.98
140	77.2	1.54	1.76	48.3	1.78	2.43	36.3	1.97	2.92	26.0	2.27	3.54	20.4	2.58	3.95
150	82.6	1.54	1.76	51.7	1.78	2.43	38.9	1.97	2.91	27.9	2.28	3.52	21.8	2.57	3.98
160	88.0	1.53	1.76	55.1	1.78	2.44	41.4	1.97	2.93	29.7	2.27	3.54	23.2	2.56	4.01
170	93.4	1.53	1.77	58.5	1.78	2.44	44.0	1.97	2.92	31.5	2.26	3.55	24.6	2.55	4.03
180	98.8	1.53	1.77	61.9	1.78	2.44	46.5	1.96	2.94	33.3	2.26	3.57	26.1	2.56	4.01
190	104.2	1.54	1.77	65.3	1.78	2.44	49.1	1.97	2.93	35.2	2.27	3.55	27.5	2.56	4.03
200	109.6	1.54	1.77	68.7	1.78	2.44	51.6	1.96	2.94	37.0	2.26	3.56	28.9	2.55	4.04
220	120.5	1.54	1.77	75.5	1.78	2.44	56.8	1.97	2.93	40.7	2.26	3.56	31.8	2.55	4.04
240	131.3	1.54	1.77	82.3	1.78	2.45	61.9	1.97	2.94	44.3	2.26	3.58	34.6	2.54	4.07
260	142.1	1.54	1.77	89.1	1.78	2.45	67.0	1.97	2.94	48.0	2.26	3.58	37.5	2.55	4.06
280	152.9	1.54	1.78	95.9	1.78	2.45	72.1	1.97	2.95	51.6	2.25	3.59	40.3	2.54	4.08
300	163.7	1.54	1.78	102.6	1.78	2.46	77.2	1.97	2.95	55.3	2.26	3.59	43.2	2.54	4.08

Q cfs	V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
100	11.9	3.02	4.13									
110	13.0	2.98	4.22									
120	14.1	2.94	4.30									
130	15.2	2.91	4.36									
140	16.4	2.93	4.34									
150	17.5	2.90	4.39	14.0	3.34	4.77						
160	18.6	2.88	4.44	14.9	3.33	4.80						
170	19.8	2.89	4.41	15.7	3.27	4.92						
180	20.9	2.88	4.45	16.6	3.26	4.94						
190	22.0	2.86	4.49	17.5	3.26	4.96						
200	23.1	2.85	4.52	18.4	3.25	4.98	15.3	3.72	5.23			
220	25.4	2.85	4.53	20.2	3.24	5.01	16.7	3.66	5.36			
240	27.7	2.85	4.53	22.0	3.23	5.04	18.2	3.65	5.38			
260	30.0	2.85	4.54	23.8	3.22	5.06	19.7	3.64	5.39			
280	32.2	2.83	4.58	25.6	3.21	5.08	21.1	3.61	5.48	17.5	4.14	5.75
300	34.5	2.83	4.58	27.3	3.18	5.15	22.6	3.60	5.49	18.7	4.12	5.80

Parabolic waterway design
(Retardance "D and "C")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "C".

Grade 0.75 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	11.7	1.29	1.47	6.8	1.61	2.02																					
20	15.5	1.27	1.51	8.9	1.54	2.15																					
25	19.3	1.26	1.52	11.0	1.50	2.23	8.2	1.74	2.58																		
30	23.1	1.25	1.54	13.2	1.50	2.24	9.7	1.69	2.70	7.7	1.92	2.99															
35	27.0	1.26	1.53	15.3	1.48	2.29	11.3	1.68	2.72	8.9	1.88	3.08															
40	30.8	1.26	1.53	17.5	1.49	2.28	12.8	1.65	2.80	10.1	1.86	3.16															
45	34.5	1.25	1.55	19.6	1.47	2.31	14.4	1.65	2.80	11.3	1.84	3.21															
50	38.3	1.25	1.55	21.8	1.48	2.30	15.9	1.63	2.85	12.5	1.82	3.26	9.3	2.18	3.65												
55	42.1	1.25	1.55	24.0	1.48	2.29	17.5	1.64	2.85	13.7	1.81	3.30	10.1	2.12	3.80												
60	45.9	1.25	1.55	26.1	1.48	2.31	19.1	1.64	2.84	15.0	1.82	3.26	11.0	2.12	3.82												
65	49.6	1.25	1.56	28.2	1.47	2.33	20.6	1.63	2.88	16.2	1.81	3.29	11.9	2.11	3.84	9.9	2.38	4.08									
70	53.4	1.25	1.56	30.4	1.48	2.32	22.2	1.63	2.87	17.4	1.80	3.31	12.8	2.11	3.85	10.6	2.35	4.15									
75	57.1	1.25	1.56	32.5	1.47	2.33	23.7	1.62	2.90	18.6	1.80	3.34	13.6	2.07	3.95	11.3	2.33	4.22									
80	60.9	1.25	1.56	34.7	1.48	2.32	25.3	1.63	2.89	19.8	1.79	3.35	14.5	2.07	3.95	12.0	2.31	4.28									
90	68.4	1.25	1.56	38.9	1.47	2.34	28.4	1.62	2.91	22.2	1.78	3.39	16.3	2.07	3.97	13.4	2.28	4.38	11.1	2.62	4.59						
100	75.9	1.25	1.56	43.2	1.47	2.34	31.5	1.62	2.92	24.7	1.79	3.37	18.1	2.07	3.98	14.9	2.28	4.37	12.2	2.56	4.75						
110	83.4	1.25	1.57	47.5	1.47	2.34	34.7	1.63	2.90	27.1	1.78	3.40	19.8	2.04	4.04	16.3	2.26	4.45	13.4	2.55	4.78						
120	90.8	1.25	1.57	51.8	1.47	2.34	37.8	1.62	2.91	29.6	1.79	3.38	21.6	2.05	4.04	17.8	2.26	4.43	14.6	2.54	4.80	12.1	2.85	5.16			
130	98.3	1.25	1.57	56.0	1.47	2.35	40.9	1.62	2.92	32.0	1.78	3.40	23.4	2.05	4.04	19.2	2.24	4.49	15.7	2.51	4.91	13.0	2.81	5.29			
140	105.7	1.25	1.57	60.3	1.47	2.35	44.0	1.62	2.92	34.4	1.78	3.41	25.1	2.03	4.09	20.7	2.25	4.48	16.9	2.51	4.92	14.0	2.81	5.29			
150	113.1	1.25	1.58	64.5	1.47	2.36	47.1	1.62	2.93	36.8	1.77	3.43	26.9	2.04	4.08	22.1	2.23	4.52	18.1	2.50	4.92	15.0	2.81	5.30			
160	120.5	1.25	1.58	68.8	1.47	2.35	50.2	1.62	2.93	39.3	1.78	3.41	28.7	2.04	4.07	23.6	2.24	4.50	19.3	2.50	4.93	15.9	2.77	5.40	13.1	3.13	5.80
170	127.9	1.25	1.58	73.0	1.47	2.36	53.3	1.62	2.93	41.7	1.78	3.42	30.4	2.03	4.11	25.0	2.23	4.54	20.4	2.48	5.00	16.9	2.78	5.39	13.9	3.12	5.83
180	135.2	1.25	1.58	77.2	1.47	2.36	56.4	1.62	2.93	44.1	1.78	3.43	32.2	2.03	4.10	26.5	2.24	4.52	21.6	2.48	5.00	17.8	2.75	5.48	14.7	3.11	5.85
190	142.6	1.25	1.58	81.5	1.47	2.36	59.5	1.62	2.93	46.5	1.77	3.43	34.0	2.04	4.09	27.9	2.23	4.56	22.8	2.48	5.00	18.8	2.75	5.46	15.5	3.11	5.87
200	149.9	1.25	1.58	85.7	1.47	2.36	62.5	1.62	2.95	48.9	1.77	3.44	35.7	2.03	4.12	29.4	2.23	4.54	24.0	2.49	4.99	19.7	2.73	5.54	16.3	3.10	5.88
220	164.7	1.25	1.58	94.2	1.47	2.36	68.7	1.62	2.95	53.8	1.78	3.43	39.3	2.03	4.11	32.3	2.23	4.55	26.3	2.47	5.05	21.7	2.74	5.52	17.9	3.09	5.92
240	179.4	1.25	1.59	102.6	1.47	2.37	74,9	1.62	2.95	58.6	1.77	3.44	42.8	2.03	4.12	35.2	2.23	4.56	28.7	2.47	5.04	23.6	2.72	5.57	19.4	3.05	6.04
260	194.1	1.25	1.59	111.1	1.47	2.37	81.1	1.62	2.95	63.5	1.78	3.44	46.3	2.02	4.14	38.1	2.23	4.57	31.0	2.46	5.09	25.5	2.71	5.61	21.0	3.05	6.05
280	208.8	1.25	1.59	119.5	1.47	2.37	87.3	1.62	2.95	68.3	1.77	3.44	49.9	2.03	4.12	41.0	2.22	4.58	33.4	2.46	5.08	27.4	2.70	5.65	22.6	3.04	6.07
300	223.5	1.26	1.59	127.9	1.47	2.37	93.4	1.62	2.96	73.1	1.77	3.45	53.4	2.03	4.13	43.9	2.22	4.58	35.8	2.47	5.07	29.4	2.71	5.62	24.2	3.04	6.08

Parabolic waterway design
(Retardance "D" and "C")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "C".

Grade 1.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	13.4	1.13	1.47	8.4	1.30	2.03																					
20	17.8	1.12	1.49	11.1	1.27	2.10	7.6	1.52	2.55																		
25	22.2	1.11	1.50	13.9	1.27	2.09	9.4	1.49	2.64	7.6	1.62	2.99															
30	26.6	1.11	1.50	16.6	1.26	2.13	11.2	1.46	2.71	9.1	1.61	3.03															
35	30.9	1.11	1.52	19.3	1.25	2.15	13.0	1.45	2.75	10.5	1.57	3.14	8.0	1.80	3.59												
40	35.3	1.11	1.52	22.1	1.26	2.13	14.8	1.44	2.79	12.0	1.57	3.14	9.1	1.78	3.65												
45	39.7	1.11	1.52	24.8	1.25	2.15	16.7	1.45	2.76	13.4	1.55	3.21	10.2	1.76	3.70												
50	44.0	1.11	1.52	27.5	1.25	2.16	18.5	1.44	2.79	14.9	1.55	3.21	11.3	1.75	3.74	8.7	2.02	4.20									
55	48.3	1.11	1.53	30.2	1.25	2.16	20.3	1.43	2.80	16.3	1.54	3.26	12.4	1.75	3.76	9.5	1.99	4.30									
60	52.7	1.11	1.52	32.9	1.25	2.17	22.1	1.43	2.82	17.8	1.54	3.25	13.5	1.74	3.79	10.4	2.01	4.26									
65	57.0	1.11	1.53	35.6	1.25	2.17	23.9	1.43	2.83	19.2	1.53	3.29	14.6	1.73	3.81	11.2	1.98	4.33	9.3	2.22	4.66						
70	61.3	1.11	1.53	38.3	1.25	2.17	25.7	1.43	2.84	20.7	1.53	3.27	15.6	1.71	3.90	12.0	1.96	4.40	10.0	2.21	4.69						
75	65.6	1.11	1.53	41.0	1.25	2.18	27.5	1.42	2.85	22.1	1.53	3.31	16.7	1.71	3.90	12.8	1.95	4.46	10.7	2.21	4.71						
80	69.8	1.11	1.54	43.7	1.25	2.18	29.3	1.42	2.85	23.6	1.53	3.29	17.8	1.71	3.91	13.7	1.96	4.42	11.3	2.16	4.85						
90	78.5	1.11	1.54	49.1	1.25	2.18	32.9	1.42	2.87	26.5	1.53	3.31	20.0	1.70	3.93	15.3	1.93	4.52	12.7	2.16	4.87	10.6	2.42	5.20			
100	87.1	1.11	1.54	54.5	1.25	2.18	36.6	1.43	2.85	29.4	1.52	3.32	22.2	1.70	3.94	17.0	1.93	4.52	14.1	2.15	4.89	11.7	2.39	5.31			
110	95.6	1.11	1.54	59.9	1.25	2.18	40.2	1.42	2.86	32.3	1.52	3.33	24.4	1.70	3.94	18.7	1.93	4.52	15.4	2.12	5.00	12.9	2.40	5.28	11.1	2.59	5.67
120	104.2	1.11	1.54	65.2	1.25	2.19	43.8	1.42	2.87	35.2	1.52	3.33	26.6	1.70	3.95	20.3	1.92	4.59	16.8	2.12	5.00	14.0	2.37	5.36	12.1	2.59	5.69
130	112.7	1.11	1.55	70.6	1.25	2.19	47.4	1.42	2.87	38.1	1.52	3.34	28.8	1.70	3.95	22.0	1.92	4.58	18.2	2.13	5.00	15.1	2.35	5.44	13.0	2.55	5.83
140	121.2	1.11	1.55	76.0	1.25	2.19	51.0	1.42	2.87	41.0	1.52	3.34	30.9	1.69	3.99	23.7	1.92	4.57	19.6	2.13	5.00	16.2	2.34	5.50	14.0	2.55	5.83
150	129.7	1.11	1.55	81.3	1.25	2.19	54.6	1.42	2.87	43.9	1.52	3.34	33.1	1.69	3.99	25.3	1.91	4.62	20.9	2.11	5.07	17.4	2.35	5.46	15.0	2.55	5.84
160	138.1	1.11	1.55	86.6	1.25	2.20	58.2	1.42	2.88	46.8	1.52	3.34	35.3	1.69	3.99	27.0	1.91	4.61	22.3	2.11	5.06	18.5	2.33	5.51	15.9	2.52	5.95
170	146.6	1.11	1.55	91.9	1.25	2.20	61.7	1.42	2.89	49.7	1.52	3.34	37.5	1.69	3.99	28.7	1.92	4.60	23.7	2.11	5.05	19.6	2.32	5.56	16.9	2.52	5.94
180	155.0	1.11	1.55	97.2	1.25	2.20	65.3	1.42	2.89	52.5	1.52	3.36	39.6	1.69	4.01	30.3	1.91	4.63	25.0	2.10	5.10	20.7	2.31	5.60	17.9	2.52	5.93
190	163.4	1.11	1.55	102.5	1.25	2.20	68.9	1.42	2.89	55.4	1.52	3.36	41.8	1.69	4.01	32.0	1.91	4.62	26.4	2.10	5.09	21.9	2.32	5.56	18.8	2.50	6.02
200	171.7	1.11	1.56	107.8	1.25	2.20	72.4	1.42	2.90	58.3	1.52	3.35	44.0	1.69	4.00	33.6	1.91	4.65	27.8	2.11	5.08	23.0	2.32	5.59	19.8	2.50	6.01
220	188.7	1.11	1.56	118.4	1.25	2.21	79.6	1.42	2.89	64.0	1.52	3.37	48.4	1.70	4.00	37.0	1.91	4.63	30.5	2.10	5.12	25.3	2.32	5.59	21.7	2.48	6.08
240	205.5	1.11	1.56	129.0	1.25	2.21	86.7	1.42	2.90	69.8	1.52	3.37	52.7	1.69	4.01	40.3	1.91	4.65	33.3	2.10	5.11	27.5	2.30	5.65	23.6	2.47	6.13
260	222.4	1.11	1.56	139.6	1.25	2.21	93.9	1.42	2.90	75.5	1.52	3.38	57.1	1.69	4.01	43.6	1.91	4.66	36.0	2.10	5.14	29.8	2.30	5.64	25.6	2.48	6.11
280	239.1	1.11	1.56	150.2	1.25	2.22	101.0	1.42	2.91	81.3	1.52	3.37	61.4	1.69	4.02	46.9	1.90	4.68	38.8	2.10	5.12	32.1	2.31	5.63	27.5	2.47	6.15
300	255.9	1.11	1.56	160.8	1.25	2.22	108.1	1.42	2.91	87.0	1.52	3.38	65.7	1.69	4.03	50.3	1.91	4.66	41.5	2.10	5.14	34.3	2.30	5.68	29.5	2.48	6.12

Parabolic waterway design
(Retardance "D" and "C")

4-26467 5-68

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "C".

Grade 1.25 Percent

Q cfs	V_1 = 2.0 T	D	V_2	V_1 = 2.5 T	D	V_2	V_1 = 3.0 T	D	V_2
15	15.3	1.00	1.45	9.8	1.15	1.95	6.6	1.37	2.44
20	20.4	1.00	1.45	12.9	1.12	2.04	8.7	1.33	2.55
25	25.4	0.99	1.47	16.1	1.12	2.05	10.8	1.31	2.61
30	30.5	1.00	1.46	19.3	1.12	2.06	12.9	1.30	2.66
35	35.5	0.99	1.47	22.5	1.12	2.06	15.0	1.29	2.68
40	40.5	0.99	1.47	25.7	1.12	2.06	17.1	1.28	2.70
45	45.5	0.99	1.48	28.8	1.11	2.08	19.2	1.28	2.72
50	50.4	0.99	1.49	32.0	1.12	2.08	21.3	1.28	2.73
55	55.4	0.99	1.48	35.1	1.11	2.09	23.4	1.28	2.74
60	60.3	0.99	1.49	38.3	1.12	2.09	25.5	1.28	2.74
65	65.2	0.99	1.49	41.4	1.11	2.10	27.6	1.28	2.74
70	70.1	0.99	1.50	44.6	1.12	2.09	29.7	1.28	2.75
75	75.0	0.99	1.50	47.7	1.12	2.09	31.8	1.28	2.75
80	79.9	0.99	1.50	50.8	1.12	2.10	33.8	1.27	2.77
90	89.7	0.99	1.50	[illegible]	1.12	2.10	38.0	1.27	2.77
100	99.6	0.99	1.50	63.3	1.11	2.11	42.2	1.27	2.77
110	109.4	0.99	1.50	69.6	1.12	2.11	46.4	1.27	2.77
120	119.1	0.99	1.51	75.8	1.12	2.11	50.5	1.27	2.78
130	128.9	1.00	1.51	82.0	1.12	2.11	54.7	1.27	2.78
140	138.6	1.00	1.51	88.2	1.12	2.12	58.8	1.27	2.79
150	148.2	1.00	1.51	94.4	1.12	2.12	63.0	1.27	2.78
160	157.9	1.00	1.51	100.6	1.12	2.12	67.1	1.27	2.79
170	167.5	1.00	1.51	106.7	1.12	2.12	71.2	1.27	2.79
180	177.1	1.00	1.51	112.9	1.12	2.12	75.3	1.27	2.80
190	186.6	1.00	1.52	119.0	1.12	2.12	79.4	1.27	2.80
200	196.1	1.00	1.52	125.1	1.12	2.13	83.5	1.27	2.80
220	215.4	1.00	1.52	137.4	1.12	2.13	91.8	1.27	2.80
240	234.7	1.00	1.52	149.8	1.12	2.13	100.0	1.27	2.81
260	253.8	1.00	1.52	162.0	1.12	2.13	108.2	1.27	2.81
280	273.0	1.00	1.52	174.3	1.12	2.13	116.4	1.27	2.81
300	292.0	1.00	1.53	186.5	1.12	2.14	124.6	1.27	2.82

Q cfs	V_1 = 3.5 T	D	V_2	V_1 = 4.0 T	D	V_2	V_1 = 4.5 T	D	V_2
15									
20	6.6	1.49	2.98						
25	8.2	1.47	3.06	6.7	1.62	3.38			
30	9.7	1.43	3.20	7.9	1.56	3.58			
35	11.3	1.42	3.22	9.2	1.55	3.62	7.2	1.78	4.02
40	12.9	1.42	3.24	10.5	1.55	3.64	8.2	1.77	4.07
45	14.4	1.40	3.31	11.7	1.52	3.75	9.1	1.72	4.25
50	16.0	1.40	3.31	13.0	1.52	3.75	10.1	1.71	4.27
55	17.6	1.40	3.31	14.3	1.52	3.75	11.1	1.71	4.29
60	19.1	1.39	3.36	15.6	1.52	3.75	12.1	1.71	4.30
65	20.7	1.39	3.35	16.8	1.51	3.81	13.0	1.68	4.41
70	22.3	1.39	3.35	18.1	1.51	3.80	14.0	1.68	4.41
75	23.8	1.39	3.38	19.4	1.51	3.80	15.0	1.68	4.40
80	25.4	1.39	3.37	20.6	1.50	3.84	16.0	1.69	4.40
90	28.5	1.38	3.39	23.2	1.51	3.83	17.9	1.67	4.48
100	31.7	1.39	3.38	25.7	1.50	3.86	19.9	1.67	4.47
110	34.8	1.39	3.39	28.3	1.50	3.85	21.9	1.67	4.46
120	37.9	1.38	3.41	30.8	1.50	3.87	23.8	1.66	4.51
130	41.1	1.39	3.39	33.3	1.49	3.89	25.8	1.67	4.50
140	44.2	1.39	3.40	35.9	1.50	3.87	27.8	1.67	4.48
150	47.3	1.39	3.41	38.4	1.50	3.88	29.7	1.66	4.52
160	50.4	1.39	3.41	40.9	1.50	3.89	31.7	1.67	4.51
170	53.5	1.39	3.41	43.4	1.49	3.90	33.6	1.66	4.53
180	56.6	1.39	3.42	46.0	1.50	3.88	35.6	1.67	4.52
190	59.7	1.39	3.42	48.5	1.50	3.89	37.5	1.66	4.54
200	62.8	1.39	3.42	51.0	1.50	3.90	39.5	1.67	4.52
220	69.0	1.39	3.42	56.0	1.50	3.91	43.4	1.67	4.53
240	75.2	1.39	3.43	61.1	1.50	3.90	47.3	1.67	4.54
260	81.4	1.39	3.43	66.1	1.50	3.91	51.2	1.66	4.55
280	87.6	1.39	3.43	71.1	1.50	3.92	55.1	1.67	4.55
300	93.7	1.39	3.44	76.2	1.50	3.91	59.0	1.67	4.55

Q cfs	V_1 = 5.0 T	D	V_2	V_1 = 5.5 T	D	V_2	V_1 = 6.0 T	D	V_2
15									
20									
25									
30									
35									
40									
45									
50	8.3	1.95	4.57						
55	9.1	1.93	4.63						
60	9.9	1.92	4.67						
65	10.6	1.88	4.84	8.7	2.18	5.06			
70	11.4	1.87	4.86	9.3	2.15	5.18			
75	12.2	1.87	4.88	9.9	2.12	5.28			
80	13.0	1.87	4.89	10.5	2.10	5.37	9.2	2.33	5.51
90	14.6	1.86	4.92	11.8	2.09	5.40	10.3	2.31	5.60
100	16.2	1.85	4.94	13.1	2.09	5.42	11.4	2.29	5.68
110	17.8	1.85	4.96	14.4	2.09	5.43	12.4	2.24	5.88
120	19.3	1.83	5.05	15.6	2.06	5.55	13.5	2.23	5.91
130	20.9	1.83	5.05	16.9	2.06	5.55	14.6	2.22	5.95
140	22.5	1.83	5.06	18.2	2.06	5.55	15.7	2.22	5.97
150	24.1	1.83	5.06	19.4	2.04	5.63	16.8	2.21	6.00
160	25.7	1.83	5.06	20.7	2.05	5.62	17.9	2.21	6.01
170	27.3	1.83	5.06	22.0	2.05	5.62	19.0	2.21	6.03
180	28.9	1.84	5.05	23.3	2.05	5.61	20.1	2.21	6.04
190	30.4	1.83	5.10	24.5	2.04	5.67	21.2	2.20	6.05
200	32.0	1.83	5.09	25.8	2.04	5.66	22.3	2.20	6.06
220	35.2	1.83	5.09	28.3	2.03	5.70	24.5	2.20	6.08
240	38.4	1.83	5.09	30.9	2.04	5.68	26.7	2.20	6.10
260	41.5	1.83	5.12	33.4	2.03	5.72	28.8	2.18	6.18
280	44.7	1.83	5.11	36.0	2.03	5.70	31.0	2.18	6.18
300	47.8	1.82	5.13	38.5	2.03	5.73	33.2	2.18	6.19

Parabolic waterway design
(Retardance "D" and "C")

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "C".

Grade 1.50 Percent

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	17.0	0.92	1.42	11.3	1.05	1.86	7.6	1.20	2.41																		
20	22.7	0.92	1.41	14.9	1.03	1.93	10.0	1.17	2.53	7.0	1.40	3.01	5.7	1.52	3.39												
25	28.3	0.92	1.42	18.6	1.03	1.94	12.4	1.15	2.59	8.6	1.35	3.19	7.0	1.46	3.60												
30	33.9	0.92	1.43	22.3	1.03	1.94	14.9	1.15	2.59	10.3	1.34	3.22	8.4	1.46	3.62	6.9	1.59	4.03									
35	39.5	0.92	1.43	26.0	1.03	1.95	17.3	1.14	2.62	11.9	1.31	3.32	9.7	1.43	3.74	8.0	1.56	4.13									
40	45.0	0.92	1.44	29.7	1.03	1.94	19.8	1.15	2.61	13.6	1.31	3.32	11.1	1.43	3.73	9.1	1.55	4.20	7.1	1.79	4.64						
45	50.5	0.92	1.44	33.3	1.02	1.96	22.2	1.14	2.63	15.2	1.30	3.39	12.4	1.41	3.81	10.2	1.54	4.25	8.0	1.79	4.63						
50	56.1	0.92	1.44	37.0	1.03	1.95	24.6	1.14	2.65	16.9	1.30	3.38	13.7	1.39	3.88	11.3	1.53	4.29	8.8	1.75	4.78						
55	61.5	0.92	1.45	40.6	1.02	1.96	27.1	1.14	2.64	18.6	1.30	3.37	15.1	1.40	3.86	12.4	1.52	4.32	9.6	1.73	4.91	8.2	1.93	5.14			
60	67.0	0.92	1.45	44.2	1.02	1.97	29.5	1.14	2.65	20.2	1.29	3.41	16.4	1.39	3.91	13.5	1.52	4.35	10.5	1.73	4.88	8.9	1.91	5.23			
65	72.5	0.92	1.45	47.8	1.02	1.98	31.9	1.14	2.66	21.9	1.30	3.40	17.8	1.40	3.88	14.6	1.51	4.37	11.3	1.71	4.97	9.6	1.89	5.30			
70	77.9	0.92	1.45	51.4	1.02	1.98	34.3	1.14	2.66	23.5	1.29	3.43	19.1	1.39	3.92	15.7	1.51	4.39	12.2	1.72	4.94	10.3	1.88	5.36	8.8	2.12	5.55
75	83.3	0.92	1.46	55.0	1.02	1.98	36.7	1.14	2.67	25.2	1.29	3.42	20.5	1.40	3.89	16.8	1.51	4.40	13.0	1.70	5.02	11.0	1.87	5.41	9.4	2.10	5.61
80	88.7	0.92	1.46	58.6	1.02	1.98	39.1	1.14	2.67	26.8	1.29	3.44	21.8	1.39	3.93	17.9	1.50	4.41	13.9	1.71	4.98	11.7	1.86	5.46	9.9	2.05	5.83
90	99.6	0.92	1.46	65.8	1.02	1.99	44.0	1.14	2.66	30.1	1.29	3.46	24.5	1.39	3.93	20.1	1.50	4.43	15.6	1.71	5.02	13.2	1.87	5.42	11.1	2.04	5.90
100	110.5	0.92	1.46	73.0	1.02	1.99	48.8	1.14	2.67	33.4	1.29	3.47	27.2	1.39	3.94	22.3	1.50	4.45	17.3	1.70	5.05	14.6	1.85	5.50	12.3	2.03	5.95
110	121.4	0.92	1.46	80.2	1.02	1.99	53.6	1.14	2.68	36.7	1.28	3.47	29.9	1.39	3.94	24.5	1.50	4.46	19.0	1.70	5.07	16.0	1.84	5.56	13.5	2.02	6.00
120	132.2	0.92	1.46	87.3	1.02	2.00	58.4	1.14	2.68	40.0	1.28	3.48	32.6	1.39	3.95	26.7	1.49	4.47	20.7	1.69	5.09	17.5	1.85	5.52	14.7	2.01	6.03
130	142.9	0.92	1.47	94.5	1.02	2.00	63.2	1.14	2.68	43.3	1.29	3.48	35.3	1.39	3.94	28.9	1.49	4.48	22.4	1.69	5.10	18.9	1.84	5.57	15.9	2.00	6.06
140	153.6	0.92	1.47	101.6	1.02	2.00	68.0	1.14	2.69	46.6	1.29	3.48	37.9	1.38	3.97	31.1	1.49	4.48	24.0	1.68	5.18	20.3	1.83	5.61	17.1	2.00	6.08
150	164.3	0.92	1.47	108.7	1.03	2.00	72.8	1.14	2.68	49.9	1.29	3.48	40.6	1.39	3.97	33.3	1.49	4.49	25.7	1.68	5.18	21.7	1.82	5.64	18.3	2.00	6.10
160	175.0	0.92	1.47	115.7	1.02	2.01	77.6	1.14	2.68	53.2	1.29	3.48	43.3	1.39	3.97	35.5	1.50	4.49	27.4	1.68	5.19	23.2	1.83	5.60	19.5	1.99	6.12
170	185.6	0.92	1.48	122.8	1.03	2.01	82.3	1.14	2.69	56.4	1.29	3.49	45.9	1.38	3.99	37.7	1.50	4.49	29.1	1.68	5.19	24.6	1.83	5.63	20.7	1.99	6.13
180	196.2	0.92	1.48	129.8	1.02	2.01	87.1	1.14	2.69	59.7	1.29	3.49	48.6	1.39	3.98	39.8	1.49	4.52	30.8	1.68	5.19	26.0	1.82	5.66	21.9	1.99	6.14
190	206.7	0.92	1.48	136.8	1.03	2.02	91.8	1.14	2.69	62.9	1.29	3.50	51.3	1.39	3.97	42.0	1.49	4.52	32.5	1.68	5.18	27.4	1.82	5.68	23.1	1.99	6.15
200	217.2	0.92	1.48	143.8	1.03	2.02	96.5	1.14	2.70	66.2	1.29	3.49	53.9	1.39	3.99	44.2	1.49	4.51	34.2	1.68	5.18	28.9	1.83	5.64	24.3	1.99	6.16
220	238.5	0.92	1.48	157.9	1.03	2.02	106.0	1.14	2.70	72.7	1.29	3.50	59.3	1.39	3.98	48.6	1.50	4.51	37.6	1.68	5.19	31.7	1.82	5.68	26.7	1.99	6.18
240	259.7	0.92	1.49	172.0	1.03	2.02	115.6	1.15	2.70	79.3	1.29	3.50	64.6	1.39	3.99	53.0	1.50	4.51	40.9	1.67	5.23	34.6	1.82	5.67	29.1	1.98	6.19
260	280.9	0.92	1.49	186.1	1.03	2.03	125.0	1.15	2.71	85.8	1.29	3.51	69.9	1.39	3.99	57.3	1.49	4.53	44.3	1.68	5.22	37.4	1.82	5.70	31.5	1.98	6.20
280	302.0	0.92	1.49	200.1	1.03	2.03	134.5	1.15	2.71	92.3	1.29	3.51	75.2	1.39	4.00	61.7	1.50	4.53	47.7	1.68	5.22	40.3	1.82	5.69	33.9	1.98	6.21
300	323.0	0.93	1.49	214.1	1.03	2.03	143.9	1.15	2.71	98.8	1.29	3.51	80.5	1.39	4.00	66.0	1.49	4.54	51.1	1.68	5.21	43.1	1.82	5.71	36.3	1.98	6.21

Parabolic waterway design
(Retardance "D" and "C")

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V_1 for <u>RETARDANCE "D"</u>. Top Width (T), Depth (D) and V_2 for <u>RETARDANCE "C"</u>.

Grade 1.75 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	18.5	0.87	1.38	12.1	0.97	1.89	8.5	1.08	2.40	5.9	1.28	2.92															
20	24.5	0.86	1.41	16.1	0.96	1.91	11.3	1.07	2.43	7.8	1.25	3.03	6.5	1.34	3.38												
25	30.6	0.86	1.41	20.1	0.96	1.91	14.1	1.07	2.45	9.7	1.23	3.09	8.1	1.33	3.43	5.6	1.46	3.81									
30	36.7	0.86	1.40	24.1	0.96	1.92	16.8	1.06	2.50	11.6	1.22	3.13	9.6	1.29	3.57	7.8	1.41	4.01									
35	42.7	0.86	1.41	28.1	0.96	1.92	19.6	1.06	2.50	13.4	1.20	3.23	11.2	1.29	3.58	9.1	1.41	4.02	7.1	1.59	4.57						
40	48.7	0.86	1.42	32.0	0.96	1.93	22.4	1.06	2.50	15.3	1.20	3.24	12.7	1.27	3.67	10.3	1.38	4.15	8.1	1.58	4.61						
45	54.7	0.86	1.42	36.0	0.96	1.93	25.1	1.05	2.53	17.2	1.20	3.24	14.3	1.28	3.66	11.6	1.39	4.14	9.1	1.57	4.64	7.5	1.73	5.12			
50	60.7	0.86	1.42	39.9	0.96	1.94	27.9	1.06	2.52	19.1	1.20	3.25	15.8	1.26	3.72	12.8	1.37	4.22	10.0	1.54	4.80	8.3	1.71	5.20			
55	66.6	0.86	1.42	43.8	0.96	1.94	30.6	1.05	2.53	21.0	1.20	3.25	17.4	1.27	3.70	14.1	1.37	4.21	11.0	1.54	4.80	9.1	1.70	5.25	7.5	1.91	5.65
60	72.5	0.86	1.43	47.7	0.96	1.95	33.3	1.05	2.55	22.8	1.19	3.29	18.9	1.26	3.75	15.4	1.38	4.19	12.0	1.54	4.81	9.9	1.69	5.30	8.2	1.92	5.63
65	78.4	0.86	1.43	51.6	0.96	1.95	36.1	1.06	2.54	24.7	1.19	3.28	20.5	1.26	3.73	16.6	1.37	4.25	12.9	1.52	4.92	10.7	1.68	5.34	8.8	1.88	5.79
70	84.3	0.86	1.43	55.5	0.96	1.95	38.8	1.05	2.54	26.6	1.19	3.28	22.0	1.26	3.76	17.9	1.37	4.23	13.9	1.52	4.91	11.5	1.68	5.38	9.5	1.89	5.76
75	90.0	0.86	1.43	59.4	0.96	1.95	41.5	1.05	2.55	28.5	1.20	3.27	23.6	1.26	3.74	19.1	1.36	4.28	14.9	1.52	4.90	12.3	1.67	5.40	10.1	1.87	5.89
80	96.0	0.86	1.43	63.2	0.96	1.96	44.2	1.05	2.56	30.3	1.19	3.30	25.1	1.26	3.77	20.4	1.37	4.25	15.9	1.53	4.89	13.1	1.67	5.43	10.8	1.88	5.85
90	107.8	0.86	1.44	71.0	0.96	1.96	49.7	1.05	2.55	34.1	1.19	3.29	28.2	1.26	3.78	22.9	1.37	4.28	17.8	1.51	4.96	14.7	1.66	5.47	12.1	1.86	5.93
100	119.5	0.86	1.44	78.8	0.96	1.96	55.1	1.05	2.56	37.8	1.19	3.31	31.3	1.26	3.79	25.4	1.36	4.30	19.8	1.52	4.94	16.3	1.65	5.51	13.4	1.85	5.99
110	131.2	0.86	1.44	86.5	0.96	1.97	60.5	1.05	2.57	41.5	1.19	3.32	34.4	1.26	3.79	27.9	1.36	4.31	21.7	1.51	4.99	17.9	1.65	5.53	14.7	1.84	6.05
120	142.9	0.86	1.44	94.2	0.96	1.97	65.9	1.05	2.58	45.3	1.19	3.31	37.5	1.26	3.79	30.4	1.36	4.32	23.7	1.51	4.97	19.5	1.65	5.55	16.0	1.83	6.09
130	154.5	0.86	1.45	101.9	0.96	1.97	71.3	1.05	2.58	49.0	1.19	3.31	40.6	1.26	3.79	32.9	1.36	4.33	25.6	1.51	5.01	21.1	1.65	5.57	17.3	1.82	6.12
140	166.1	0.87	1.45	109.6	0.96	1.97	76.7	1.05	2.58	52.7	1.19	3.32	43.7	1.26	3.79	35.4	1.36	4.33	27.6	1.51	4.99	22.7	1.64	5.58	18.6	1.82	6.15
150	177.6	0.87	1.45	117.2	0.96	1.98	82.1	1.05	2.58	56.4	1.19	3.32	46.8	1.26	3.79	37.9	1.36	4.33	29.5	1.51	5.02	24.3	1.64	5.59	19.9	1.82	6.17
160	189.1	0.87	1.45	124.8	0.96	1.98	87.5	1.06	2.58	60.1	1.19	3.33	49.8	1.26	3.81	40.4	1.36	4.33	31.4	1.50	5.04	25.9	1.64	5.60	21.3	1.83	6.10
170	200.5	0.87	1.45	132.4	0.96	1.98	92.8	1.05	2.58	63.7	1.19	3.34	52.9	1.26	3.80	42.9	1.36	4.33	33.4	1.51	5.02	27.5	1.64	5.60	22.6	1.83	6.13
180	211.9	0.87	1.46	140.0	0.96	1.98	98.1	1.05	2.59	67.4	1.19	3.34	55.9	1.26	3.82	45.4	1.36	4.33	35.3	1.51	5.04	29.1	1.64	5.61	23.9	1.83	6.14
190	223.3	0.87	1.46	147.5	0.96	1.99	103.4	1.05	2.59	71.1	1.19	3.34	59.0	1.26	3.81	47.8	1.36	4.36	37.2	1.50	5.06	30.7	1.64	5.61	25.2	1.82	6.16
200	234.6	0.87	1.46	155.1	0.97	1.99	108.7	1.06	2.60	74.7	1.19	3.35	62.0	1.26	3.82	50.3	1.36	4.35	39.2	1.51	5.03	32.3	1.64	5.61	26.5	1.82	6.17
220	257.6	0.87	1.46	170.3	0.96	1.99	119.4	1.06	2.60	82.1	1.19	3.35	68.1	1.26	3.83	55.3	1.36	4.35	43.1	1.51	5.03	35.5	1.64	5.62	29.1	1.82	6.20
240	280.4	0.87	1.47	185.5	0.97	1.99	130.1	1.06	2.60	89.5	1.19	3.35	74.3	1.26	3.82	60.3	1.36	4.35	46.9	1.51	5.06	38.7	1.64	5.62	31.7	1.81	6.22
260	303.2	0.87	1.47	200.6	0.97	2.00	140.8	1.06	2.60	96.9	1.19	3.35	80.4	1.26	3.82	65.2	1.36	4.37	50.8	1.51	5.06	41.9	1.64	5.63	34.3	1.81	6.24
280	326.0	0.87	1.47	215.7	0.97	2.00	151.4	1.06	2.61	104.2	1.19	3.36	86.5	1.26	3.83	70.2	1.36	4.36	54.7	1.51	5.05	45.1	1.64	5.63	36.9	1.81	6.25
300	348.6	0.87	1.47	230.8	0.97	2.00	162.0	1.06	2.61	111.5	1.19	3.36	92.5	1.26	3.84	75.1	1.36	4.37	58.5	1.51	5.07	48.3	1.65	5.63	39.5	1.81	6.26

Parabolic waterway design
(Retardance "D" and "C")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "C".

Grade 2.0 Percent

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	20.8	0.81	1.32	12.8	0.91	1.90	9.3	1.00	2.37	6.7	1.15	2.85															
20	27.6	0.80	1.33	17.1	0.91	1.89	12.3	0.99	2.43	8.8	1.12	3.00	6.5	1.29	3.51	5.4	1.41	3.84									
25	34.5	0.81	1.33	21.3	0.91	1.91	15.4	0.99	2.43	11.0	1.11	3.01	8.0	1.25	3.69	6.7	1.38	3.96									
30	41.3	0.81	1.34	25.5	0.91	1.92	18.4	0.98	2.46	13.2	1.11	3.02	9.6	1.24	3.71	7.9	1.33	4.20	6.6	1.49	4.48						
35	48.0	0.80	1.35	29.7	0.91	1.93	21.5	0.99	2.44	15.3	1.10	3.08	11.1	1.22	3.82	9.2	1.33	4.23	7.6	1.45	4.68						
40	54.8	0.80	1.34	33.9	0.91	1.93	24.5	0.98	2.46	17.5	1.10	3.07	12.7	1.22	3.81	10.5	1.32	4.26	8.7	1.45	4.67	7.2	1.65	4.96			
45	61.5	0.80	1.35	38.1	0.91	1.93	27.5	0.98	2.47	19.6	1.10	3.11	14.3	1.23	3.80	11.8	1.32	4.27	9.7	1.43	4.80	8.0	1.61	5.16			
50	68.2	0.80	1.35	42.3	0.91	1.93	30.5	0.98	2.48	21.8	1.10	3.09	15.8	1.22	3.86	13.1	1.32	4.28	10.8	1.43	4.78	8.8	1.57	5.33	7.5	1.74	5.64
55	74.9	0.81	1.35	46.4	0.91	1.94	33.5	0.98	2.48	23.9	1.09	3.12	17.4	1.22	3.84	14.4	1.32	4.29	11.8	1.42	4.87	9.7	1.58	5.30	8.2	1.72	5.75
60	81.5	0.81	1.36	50.6	0.91	1.93	36.5	0.98	2.49	26.1	1.10	3.10	18.9	1.21	3.89	15.6	1.30	4.38	12.9	1.42	4.84	10.6	1.59	5.28	9.0	1.74	5.65
65	88.1	0.81	1.36	54.7	0.91	1.94	39.5	0.98	2.49	28.2	1.10	3.12	20.5	1.22	3.87	16.9	1.30	4.38	13.9	1.41	4.92	11.4	1.56	5.40	9.7	1.73	5.74
70	94.7	0.81	1.36	58.8	0.91	1.94	42.5	0.98	2.49	30.3	1.09	3.14	22.0	1.21	3.90	18.2	1.31	4.37	15.0	1.42	4.89	12.3	1.57	5.37	10.4	1.71	5.82
75	101.2	0.81	1.36	62.9	0.91	1.94	45.5	0.99	2.49	32.4	1.09	3.15	23.6	1.22	3.88	19.5	1.31	4.37	16.0	1.41	4.95	13.1	1.55	5.46	11.1	1.70	5.89
80	107.8	0.81	1.36	67.0	0.91	1.95	48.4	0.98	2.50	34.6	1.10	3.13	25.1	1.21	3.91	20.7	1.30	4.42	17.1	1.41	4.91	14.0	1.56	5.43	11.8	1.69	5.95
90	121.0	0.81	1.37	75.2	0.91	1.95	54.4	0.98	2.50	38.8	1.09	3.15	28.2	1.21	3.92	23.3	1.30	4.41	19.2	1.41	4.94	15.7	1.55	5.48	13.3	1.69	5.92
100	134.2	0.81	1.37	83.4	0.91	1.96	60.4	0.99	2.50	43.1	1.10	3.15	31.3	1.21	3.93	25.9	1.30	4.40	21.3	1.41	4.96	17.4	1.55	5.52	14.7	1.68	6.02
110	147.3	0.81	1.37	91.6	0.91	1.96	66.3	0.98	2.51	47.4	1.10	3.15	34.4	1.21	3.93	28.4	1.30	4.44	23.4	1.40	4.98	19.1	1.54	5.55	16.2	1.68	5.99
120	160.3	0.81	1.38	99.8	0.91	1.96	72.2	0.98	2.51	51.6	1.10	3.16	37.5	1.21	3.93	31.0	1.30	4.42	25.5	1.40	4.99	20.8	1.54	5.58	17.6	1.67	6.06
130	173.3	0.81	1.38	107.9	0.91	1.96	78.1	0.98	2.51	55.8	1.09	3.17	40.6	1.21	3.93	33.5	1.30	4.45	27.6	1.40	5.00	22.5	1.53	5.60	19.1	1.68	6.03
140	186.3	0.81	1.38	116.0	0.91	1.97	84.0	0.99	2.52	60.1	1.10	3.16	43.6	1.21	3.96	36.0	1.29	4.47	29.7	1.40	5.00	24.2	1.53	5.62	20.5	1.67	6.08
150	199.2	0.81	1.38	124.1	0.91	1.97	89.9	0.99	2.52	64.3	1.10	3.16	46.7	1.21	3.96	38.6	1.30	4.45	31.8	1.40	5.00	25.9	1.53	5.63	21.9	1.66	6.13
160	212.0	0.81	1.38	132.1	0.91	1.97	95.7	0.99	2.52	68.5	1.10	3.17	49.8	1.21	3.95	41.1	1.30	4.47	33.8	1.40	5.05	27.6	1.53	5.64	23.4	1.67	6.09
170	224.8	0.81	1.39	140.2	0.91	1.97	101.6	0.99	2.52	72.7	1.10	3.17	52.8	1.21	3.97	43.6	1.30	4.48	35.9	1.40	5.05	29.3	1.53	5.65	24.8	1.66	6.13
180	237.5	0.81	1.39	148.2	0.91	1.98	107.4	0.99	2.53	76.8	1.10	3.18	55.9	1.21	3.96	46.2	1.30	4.46	38.0	1.40	5.04	31.0	1.53	5.65	26.3	1.67	6.10
190	250.2	0.81	1.39	156.1	0.91	1.98	113.2	0.99	2.53	81.0	1.10	3.18	58.9	1.21	3.97	48.7	1.30	4.47	40.1	1.40	5.04	32.7	1.53	5.65	27.7	1.67	6.13
200	262.8	0.81	1.39	164.1	0.91	1.98	119.0	0.99	2.53	85.2	1.10	3.18	61.9	1.21	3.98	51.2	1.30	4.48	42.2	1.40	5.03	34.4	1.53	5.66	29.1	1.66	6.16
220	288.5	0.81	1.40	180.2	0.91	1.99	130.7	0.99	2.54	93.6	1.10	3.18	68.1	1.21	3.97	56.3	1.30	4.48	46.3	1.40	5.06	37.8	1.53	5.67	32.0	1.66	6.16
240	314.1	0.81	1.40	196.2	0.91	1.99	142.4	0.99	2.54	102.0	1.10	3.19	74.2	1.21	3.98	61.3	1.30	4.50	50.5	1.40	5.06	41.2	1.53	5.68	34.9	1.66	6.16
260	339.5	0.81	1.40	212.2	0.91	1.99	154.0	0.99	2.54	110.3	1.10	3.20	80.3	1.21	3.98	66.4	1.30	4.49	54.7	1.40	5.05	44.6	1.53	5.68	37.8	1.66	6.16
280	364.9	0.81	1.40	228.2	0.92	1.99	165.6	0.99	2.55	118.7	1.10	3.19	86.3	1.21	4.00	71.4	1.30	4.50	58.8	1.40	5.07	48.0	1.53	5.68	40.6	1.66	6.20
300	390.2	0.81	1.40	244.1	0.92	2.00	177.2	0.99	2.55	127.0	1.10	3.20	92.4	1.21	4.00	76.4	1.30	4.51	63.0	1.40	5.06	51.4	1.53	5.68	43.5	1.66	6.19

Parabolic waterway design
(Retardance "D" and "C")

4-26467 5-68

4-26467 1-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "C".

Grade 3.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	23.6	0.69	1.35	16.3	0.76	1.80	11.4	0.83	2.33	8.8	0.90	2.77	6.5	1.01	3.37	5.0	1.16	3.78									
20	31.4	0.69	1.36	21.7	0.76	1.81	15.2	0.83	2.34	11.7	0.90	2.81	8.6	0.99	3.48	6.6	1.13	3.94	5.9	1.19	4.17						
25	39.2	0.69	1.36	27.0	0.75	1.83	19.0	0.83	2.33	14.6	0.90	2.83	10.8	0.99	3.44	8.1	1.09	4.18	7.3	1.16	4.33	6.0	1.27	4.80			
30	46.9	0.69	1.37	32.4	0.75	1.82	22.7	0.83	2.36	17.4	0.88	2.89	12.9	0.98	3.49	9.7	1.08	4.22	8.7	1.15	4.44	7.1	1.24	5.03	5.8	1.41	5.37
35	54.6	0.69	1.37	37.7	0.75	1.83	26.4	0.83	2.38	20.3	0.89	2.88	15.0	0.98	3.53	11.3	1.08	4.25	10.1	1.13	4.51	8.3	1.24	5.02	6.7	1.38	5.55
40	62.2	0.69	1.37	43.0	0.75	1.83	30.2	0.83	2.37	23.2	0.89	2.88	17.1	0.98	3.55	12.9	1.08	4.26	11.5	1.13	4.57	9.4	1.22	5.17	7.6	1.36	5.70
45	69.9	0.70	1.37	48.3	0.75	1.83	33.9	0.83	2.37	26.0	0.88	2.90	19.2	0.97	3.57	14.5	1.08	4.27	12.9	1.12	4.61	10.6	1.22	5.14	8.5	1.34	5.81
50	77.4	0.69	1.38	53.5	0.75	1.84	37.6	0.83	2.38	28.9	0.89	2.89	21.3	0.97	3.58	16.0	1.06	4.36	14.3	1.12	4.63	11.7	1.21	5.24	9.4	1.33	5.90
55	85.0	0.70	1.38	58.7	0.75	1.85	41.2	0.83	2.40	31.7	0.89	2.91	23.4	0.97	3.58	17.6	1.06	4.35	15.7	1.11	4.66	12.9	1.21	5.20	10.4	1.35	5.80
60	92.5	0.70	1.38	64.0	0.75	1.84	44.9	0.83	2.40	34.5	0.88	2.92	25.5	0.97	3.59	19.2	1.07	4.35	17.1	1.11	4.67	14.0	1.20	5.28	11.3	1.34	5.87
65	99.9	0.69	1.39	69.1	0.75	1.85	48.6	0.83	2.39	37.3	0.88	2.93	27.6	0.97	3.59	20.8	1.07	4.34	18.5	1.11	4.69	15.2	1.21	5.24	12.2	1.33	5.93
70	107.3	0.69	1.39	74.3	0.75	1.86	52.2	0.83	2.40	40.1	0.88	2.93	29.7	0.98	3.59	22.3	1.06	4.39	19.9	1.11	4.69	16.3	1.20	5.30	13.1	1.32	5.98
75	114.7	0.70	1.39	79.4	0.75	1.86	55.8	0.83	2.41	42.9	0.88	2.94	31.8	0.98	3.59	23.9	1.06	4.38	21.3	1.11	4.70	17.5	1.21	5.26	14.0	1.32	6.02
80	122.1	0.70	1.40	84.5	0.75	1.87	59.4	0.83	2.42	45.7	0.88	2.94	33.9	0.98	3.58	25.5	1.07	4.36	22.7	1.11	4.70	18.6	1.20	5.31	15.0	1.33	5.94
90	137.0	0.70	1.40	94.9	0.75	1.87	66.7	0.83	2.42	51.4	0.89	2.93	38.0	0.97	3.61	28.6	1.06	4.40	25.5	1.11	4.72	20.9	1.20	5.33	16.8	1.32	6.01
100	151.8	0.70	1.40	105.2	0.75	1.87	74.0	0.83	2.42	57.0	0.89	2.94	42.2	0.98	3.61	31.7	1.06	4.42	28.3	1.11	4.73	23.2	1.20	5.34	18.6	1.31	6.08
110	165.6	0.70	1.41	115.5	0.75	1.87	81.3	0.83	2.42	62.6	0.89	2.95	46.4	0.98	3.61	34.9	1.06	4.40	31.0	1.10	4.78	25.5	1.20	5.34	20.5	1.32	6.04
120	181.3	0.70	1.41	125.7	0.75	1.88	88.5	0.83	2.43	68.2	0.89	2.95	50.5	0.98	3.62	38.0	1.06	4.42	33.8	1.11	4.78	27.7	1.19	5.40	22.3	1.32	6.08
130	195.9	0.70	1.41	135.9	0.76	1.88	95.7	0.83	2.43	73.7	0.89	2.96	54.6	0.98	3.63	41.1	1.06	4.43	36.6	1.11	4.77	30.0	1.19	5.40	24.2	1.32	6.04
140	210.5	0.70	1.41	146.1	0.76	1.88	102.8	0.83	2.44	79.3	0.89	2.96	58.8	0.98	3.62	44.2	1.06	4.44	39.4	1.11	4.77	32.3	1.20	5.39	26.0	1.32	6.08
150	225.0	0.70	1.42	156.2	0.76	1.89	110.0	0.83	2.44	84.8	0.89	2.96	62.9	0.98	3.63	47.3	1.06	4.44	42.1	1.11	4.80	34.6	1.20	5.38	27.8	1.31	6.11
160	239.4	0.70	1.42	166.2	0.76	1.89	117.1	0.83	2.45	90.3	0.89	2.97	67.0	0.98	3.63	50.4	1.06	4.45	44.9	1.11	4.79	36.8	1.19	5.42	29.6	1.31	6.13
170	253.7	0.70	1.42	176.2	0.76	1.90	124.2	0.83	2.45	95.8	0.89	2.97	71.1	0.98	3.64	53.5	1.06	4.45	47.7	1.11	4.78	39.1	1.20	5.41	31.5	1.32	6.09
180	268.0	0.70	1.43	186.2	0.76	1.90	131.2	0.83	2.46	101.3	0.89	2.97	75.2	0.98	3.64	56.6	1.06	4.45	50.4	1.11	4.80	41.3	1.19	5.44	33.3	1.32	6.11
190	282.2	0.70	1.43	196.1	0.76	1.90	138.3	0.83	2.46	106.7	0.89	2.98	79.2	0.98	3.65	59.7	1.07	4.45	53.1	1.11	4.81	43.6	1.20	5.42	35.1	1.32	6.12
200	296.3	0.70	1.43	206.0	0.76	1.90	145.3	0.83	2.46	112.2	0.89	2.98	83.3	0.98	3.65	62.7	1.06	4.47	55.9	1.11	4.80	45.8	1.19	5.45	36.9	1.32	6.14
220	325.1	0.70	1.44	226.1	0.76	1.91	159.5	0.83	2.47	123.2	0.89	2.98	91.5	0.98	3.65	68.9	1.06	4.47	61.4	1.11	4.81	50.4	1.20	5.43	40.6	1.32	6.12
240	353.8	0.70	1.44	246.2	0.76	1.91	173.7	0.83	2.47	134.2	0.89	2.99	99.7	0.98	3.65	75.1	1.07	4.47	66.9	1.11	4.81	54.9	1.20	5.44	44.2	1.32	6.15
260	382.4	0.70	1.44	266.1	0.76	1.92	187.8	0.83	2.48	145.1	0.89	2.99	107.8	0.98	3.67	81.3	1.07	4.47	72.4	1.11	4.82	59.4	1.20	5.45	47.8	1.31	6.17
280	410.8	0.70	1.45	286.0	0.76	1.92	201.9	0.83	2.48	156.0	0.89	3.00	116.0	0.98	3.66	87.4	1.07	4.48	77.9	1.11	4.82	63.9	1.20	5.46	51.5	1.32	6.15
300	439.0	0.70	1.45	305.8	0.76	1.92	215.9	0.83	2.49	166.9	0.89	3.00	124.1	0.98	3.67	93.6	1.07	4.47	83.3	1.11	4.83	68.4	1.20	5.46	55.1	1.32	6.17

Parabolic waterway design
(Retardance "D" and "C")

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "C".

Grade 4.0 Percent

Q cfs	V_1 = 2.0 T	D	V_2	V_1 = 2.5 T	D	V_2	V_1 = 3.0 T	D	V_2	V_1 = 3.5 T	D	V_2	V_1 = 4.0 T	D	V_2	V_1 = 4.5 T	D	V_2	V_1 = 5.0 T	D	V_2	V_1 = 5.5 T	D	V_2	V_1 = 6.0 T	D	V_2
15	27.9	0.62	1.29	19.9	0.66	1.68	13.9	0.73	2.20	10.3	0.79	2.73	7.9	0.85	3.28	6.3	0.92	3.78	4.9	1.06	4.21						
20	37.1	0.62	1.29	26.5	0.66	1.69	18.5	0.72	2.21	13.7	0.78	2.76	10.5	0.84	3.33	8.4	0.92	3.81	6.4	1.01	4.52	5.5	1.09	4.88			
25	46.2	0.62	1.30	33.0	0.66	1.70	23.0	0.72	2.24	17.1	0.78	2.77	13.1	0.84	3.35	10.5	0.92	3.82	8.0	1.01	4.55	6.8	1.06	5.09	5.7	1.20	5.34
30	55.3	0.62	1.30	39.5	0.66	1.70	27.6	0.72	2.23	20.4	0.77	2.82	15.7	0.84	3.36	12.5	0.91	3.92	9.5	0.99	4.71	8.2	1.07	5.03	6.7	1.15	5.71
35	64.3	0.62	1.31	46.0	0.66	1.71	32.1	0.72	2.25	23.8	0.78	2.81	18.3	0.84	3.37	14.6	0.91	3.90	11.1	0.99	4.70	9.5	1.06	5.15	7.8	1.15	5.77
40	73.3	0.62	1.31	52.4	0.66	1.71	36.6	0.72	2.25	27.1	0.77	2.83	20.8	0.83	3.42	16.6	0.90	3.96	12.7	1.00	4.68	10.8	1.04	5.24	8.9	1.14	5.81
45	82.2	0.62	1.32	58.8	0.66	1.72	41.1	0.72	2.26	30.4	0.77	2.85	23.4	0.84	3.41	18.7	0.91	3.94	14.2	0.98	4.77	12.2	1.05	5.17	10.0	1.14	5.83
50	91.1	0.62	1.32	65.2	0.66	1.72	45.6	0.72	2.26	33.7	0.77	2.86	26.0	0.84	3.40	20.7	0.90	3.97	15.8	0.99	4.74	13.5	1.05	5.24	11.1	1.14	5.85
55	99.9	0.62	1.32	71.5	0.66	1.73	50.1	0.72	2.26	37.0	0.77	2.86	28.5	0.84	3.43	22.8	0.91	3.95	17.9	0.98	4.80	14.8	1.04	5.28	12.2	1.14	5.87
60	108.7	0.62	1.32	77.8	0.66	1.73	54.5	0.72	2.26	40.3	0.77	2.87	31.0	0.83	3.45	24.8	0.90	3.97	18.9	0.99	4.77	16.1	1.04	5.32	13.3	1.14	5.88
65	117.4	0.62	1.33	84.1	0.66	1.73	58.9	0.72	2.27	43.6	0.77	2.87	33.6	0.84	3.43	26.8	0.90	3.99	20.4	0.98	4.81	17.5	1.05	5.26	14.3	1.12	6.00
70	126.1	0.62	1.33	90.3	0.66	1.74	63.3	0.72	2.27	46.9	0.77	2.86	36.1	0.84	3.44	28.8	0.90	4.01	21.9	0.98	4.85	18.8	1.04	5.29	15.4	1.12	6.00
75	134.7	0.62	1.33	96.5	0.66	1.74	67.7	0.72	2.28	50.1	0.77	2.88	38.6	0.84	3.45	30.9	0.91	3.98	23.5	0.98	4.82	20.1	1.04	5.31	16.5	1.13	5.99
80	143.3	0.62	1.34	102.7	0.66	1.74	72.1	0.72	2.28	53.3	0.77	2.89	41.1	0.84	3.46	32.9	0.91	3.99	25.0	0.98	4.84	21.4	1.04	5.33	17.6	1.13	5.98
90	160.8	0.62	1.34	115.2	0.66	1.75	80.9	0.72	2.28	59.9	0.77	2.89	46.2	0.84	3.46	36.9	0.90	4.01	28.1	0.98	4.85	24.0	1.04	5.38	19.7	1.12	6.07
100	178.2	0.62	1.34	127.7	0.66	1.75	89.7	0.72	2.29	66.4	0.77	2.90	51.2	0.84	3.47	41.0	0.91	4.00	31.2	0.98	4.85	26.7	1.04	5.35	21.9	1.12	6.05
110	195.4	0.62	1.35	140.1	0.66	1.76	98.5	0.72	2.29	72.9	0.77	2.90	56.2	0.84	3.48	45.0	0.90	4.02	34.3	0.98	4.85	29.3	1.04	5.37	24.1	1.12	6.03
120	212.6	0.62	1.35	152.5	0.66	1.76	107.2	0.72	2.30	79.4	0.77	2.90	61.2	0.84	3.49	49.0	0.90	4.03	37.3	0.98	4.88	31.9	1.04	5.40	26.2	1.12	6.09
130	229.6	0.62	1.35	164.8	0.66	1.76	115.9	0.72	2.30	85.9	0.77	2.91	66.2	0.84	3.49	53.0	0.90	4.03	40.4	0.98	4.87	34.6	1.04	5.36	28.4	1.12	6.07
140	246.6	0.62	1.36	177.0	0.66	1.77	124.5	0.72	2.30	92.3	0.77	2.91	71.2	0.84	3.49	57.0	0.90	4.04	43.4	0.98	4.90	37.2	1.04	5.38	30.5	1.12	6.10
150	263.5	0.62	1.36	189.1	0.66	1.77	133.2	0.73	2.30	98.7	0.77	2.92	76.2	0.84	3.49	61.0	0.91	4.04	46.5	0.98	4.88	39.8	1.04	5.39	32.7	1.12	6.08
160	280.3	0.62	1.36	201.2	0.66	1.78	141.7	0.73	2.31	105.1	0.77	2.92	81.1	0.84	3.50	65.0	0.91	4.04	49.5	0.98	4.90	42.4	1.04	5.40	34.8	1.12	6.11
170	296.9	0.62	1.37	213.3	0.67	1.78	150.3	0.73	2.31	111.5	0.78	2.92	86.0	0.84	3.51	68.9	0.91	4.05	52.5	0.98	4.91	45.0	1.04	5.40	36.9	1.12	6.13
180	313.5	0.62	1.37	225.3	0.67	1.78	158.8	0.73	2.32	117.8	0.78	2.93	90.9	0.84	3.52	72.9	0.91	4.05	55.6	0.98	4.90	47.6	1.04	5.40	39.1	1.12	6.11
190	330.0	0.62	1.37	237.2	0.67	1.79	167.3	0.73	2.32	124.2	0.78	2.93	95.8	0.84	3.52	76.8	0.91	4.06	58.6	0.98	4.90	50.2	1.04	5.40	41.2	1.12	6.12
200	346.4	0.62	1.37	249.1	0.67	1.79	175.7	0.73	2.32	130.5	0.78	2.93	100.7	0.84	3.52	80.7	0.91	4.07	61.6	0.98	4.91	52.7	1.04	5.43	43.3	1.12	6.14
220	380.0	0.62	1.38	273.3	0.67	1.79	192.9	0.73	2.33	143.3	0.78	2.93	110.6	0.84	3.53	88.7	0.91	4.07	67.6	0.98	4.93	57.9	1.04	5.44	47.6	1.12	6.14
240	413.3	0.62	1.38	297.4	0.67	1.80	209.9	0.73	2.33	156.0	0.78	2.94	120.4	0.84	3.53	96.6	0.91	4.07	73.7	0.98	4.93	63.1	1.04	5.44	51.9	1.12	6.14
260	446.5	0.62	1.39	321.4	0.67	1.80	227.0	0.73	2.33	168.7	0.78	2.94	130.2	0.84	3.54	104.5	0.91	4.08	79.7	0.98	4.94	68.3	1.04	5.44	56.2	1.12	6.13
280	479.5	0.62	1.39	345.3	0.67	1.80	243.9	0.73	2.34	181.3	0.78	2.95	140.0	0.84	3.54	112.3	0.91	4.09	85.8	0.99	4.93	73.5	1.04	5.44	60.4	1.12	6.15
300	512.3	0.62	1.39	369.0	0.67	1.81	260.8	0.73	2.34	193.9	0.78	2.95	149.8	0.84	3.55	120.2	0.91	4.09	91.8	0.99	4.94	78.6	1.04	5.46	64.7	1.12	6.14

Parabolic waterway design
(Retardance "D" and "C")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "C".

Grade 5.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0		
	T	D	V_2	T	D	V_2	T	D	V_2
15	29.3	0.57	1.33	21.1	0.60	1.74	15.0	0.66	2.23
20	39.0	0.57	1.33	28.1	0.61	1.74	19.9	0.66	2.26
25	48.6	0.57	1.34	35.1	0.61	1.73	24.8	0.66	2.28
30	58.1	0.57	1.34	42.0	0.61	1.74	29.7	0.66	2.28
35	67.6	0.57	1.35	48.8	0.61	1.75	34.6	0.66	2.28
40	77.0	0.57	1.35	55.7	0.61	1.75	39.5	0.66	2.28
45	86.4	0.57	1.35	62.5	0.61	1.75	44.3	0.66	2.29
50	95.7	0.57	1.36	69.2	0.61	1.76	49.1	0.66	2.30
55	105.0	0.57	1.36	75.9	0.61	1.77	53.9	0.66	2.30
60	114.2	0.57	1.36	82.6	0.61	1.77	58.7	0.66	2.30
65	123.4	0.57	1.36	89.3	0.61	1.77	63.4	0.66	2.31
70	132.4	0.57	1.37	95.9	0.61	1.77	68.2	0.66	2.31
75	141.5	0.57	1.37	102.4	0.61	1.78	72.9	0.66	2.31
80	150.5	0.57	1.37	109.0	0.61	1.78	77.5	0.66	2.32
90	168.8	0.57	1.38	122.3	0.61	1.79	87.0	0.66	2.33
100	187.0	0.57	1.38	135.5	0.61	1.79	96.5	0.66	2.33
110	205.1	0.57	1.38	148.7	0.61	1.79	105.9	0.66	2.33
120	223.1	0.57	1.39	161.8	0.61	1.80	115.3	0.66	2.33
130	240.9	0.57	1.39	174.8	0.61	1.80	124.6	0.66	2.34
140	258.7	0.57	1.40	187.7	0.61	1.81	133.9	0.66	2.34
150	276.4	0.58	1.40	200.6	0.61	1.81	143.1	0.66	2.35
160	293.9	0.58	1.40	213.4	0.61	1.81	152.3	0.66	2.35
170	311.4	0.58	1.40	226.1	0.61	1.82	161.5	0.66	2.35
180	328.7	0.58	1.41	238.8	0.61	1.82	170.6	0.66	2.36
190	346.0	0.58	1.41	251.4	0.61	1.83	179.7	0.67	2.36
200	363.1	0.58	1.42	263.9	0.61	1.83	188.7	0.67	2.37
220	398.3	0.58	1.42	289.6	0.62	1.83	207.1	0.67	2.37
240	433.2	0.58	1.42	315.0	0.62	1.84	225.4	0.67	2.37
260	467.9	0.58	1.43	340.4	0.62	1.84	243.7	0.67	2.38
280	502.5	0.58	1.43	365.6	0.62	1.84	261.8	0.67	2.38
300	536.7	0.58	1.43	390.7	0.62	1.85	279.9	0.67	2.38

Q cfs	V_1 = 3.5			V_1 = 4.0			V_1 = 4.5		
	T	D	V_2	T	D	V_2	T	D	V_2
15	12.2	0.70	2.58	9.0	0.75	3.25	7.2	0.83	3.70
20	16.2	0.70	2.62	12.0	0.75	3.26	9.5	0.81	3.84
25	20.3	0.70	2.59	15.0	0.75	3.27	11.9	0.81	3.82
30	24.3	0.70	2.61	18.0	0.76	3.26	14.2	0.80	3.89
35	28.2	0.70	2.64	20.9	0.75	3.30	16.6	0.81	3.86
40	32.2	0.70	2.64	23.9	0.75	3.29	18.9	0.80	3.90
45	36.1	0.70	2.65	26.8	0.75	3.31	21.3	0.81	3.87
50	40.1	0.70	2.64	29.7	0.75	3.32	23.6	0.81	3.89
55	44.0	0.70	2.65	32.6	0.75	3.33	25.9	0.81	3.90
60	47.9	0.70	2.66	35.5	0.75	3.34	28.2	0.81	3.92
65	51.8	0.70	2.66	38.4	0.75	3.34	30.5	0.81	3.92
70	55.6	0.70	2.67	41.3	0.75	3.34	32.8	0.81	3.93
75	59.4	0.70	2.68	44.1	0.75	3.36	35.1	0.81	3.93
80	63.3	0.70	2.68	47.0	0.75	3.36	37.4	0.81	3.92
90	71.0	0.70	2.69	52.8	0.75	3.36	42.0	0.81	3.93
100	78.7	0.70	2.70	58.5	0.75	3.37	46.5	0.81	3.96
110	86.4	0.70	2.70	64.3	0.75	3.37	51.1	0.81	3.96
120	94.1	0.70	2.70	70.0	0.75	3.38	55.7	0.81	3.96
130	101.7	0.70	2.71	75.7	0.76	3.38	60.2	0.81	3.97
140	109.3	0.70	2.71	81.3	0.75	3.39	64.7	0.81	3.98
150	116.8	0.70	2.72	87.0	0.76	3.39	69.3	0.81	3.97
160	124.3	0.70	2.72	92.6	0.76	3.40	73.7	0.81	3.99
170	131.8	0.70	2.73	98.2	0.76	3.41	78.2	0.81	3.99
180	139.2	0.70	2.73	103.8	0.76	3.41	82.7	0.81	3.99
190	146.6	0.70	2.74	109.4	0.76	3.41	87.1	0.81	4.00
200	154.0	0.70	2.74	114.9	0.76	3.42	91.6	0.81	4.00
220	169.0	0.70	2.75	126.1	0.76	3.43	100.6	0.81	4.00
240	184.0	0.70	2.75	137.4	0.76	3.43	109.5	0.81	4.01
260	198.9	0.70	2.76	148.5	0.76	3.44	118.5	0.81	4.01
280	213.7	0.70	2.76	159.7	0.76	3.44	127.4	0.81	4.02
300	228.5	0.71	2.77	170.7	0.76	3.45	136.2	0.81	4.03

Q cfs	V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2
15	5.8	0.93	4.09	4.6	0.99	4.81			
20	7.6	0.89	4.35	6.1	0.97	4.95	5.3	1.06	5.21
25	9.5	0.89	4.37	7.6	0.96	5.03	6.5	1.02	5.56
30	11.3	0.87	4.49	9.1	0.96	5.08	7.8	1.01	5.59
35	13.2	0.88	4.47	10.5	0.94	5.26	9.1	1.01	5.60
40	15.1	0.88	4.46	12.0	0.94	5.26	10.3	0.99	5.77
45	16.9	0.87	4.52	13.5	0.94	5.25	11.6	1.00	5.75
50	18.8	0.88	4.50	15.0	0.94	5.25	12.9	1.00	5.73
55	20.6	0.87	4.54	16.5	0.94	5.24	14.1	0.99	5.84
60	22.4	0.87	4.57	17.9	0.93	5.32	15.4	0.99	5.81
65	24.3	0.87	4.54	19.4	0.94	5.30	16.7	1.00	5.78
70	26.1	0.87	4.56	20.8	0.93	5.36	17.9	0.99	5.85
75	27.9	0.87	4.58	22.3	0.93	5.34	19.2	1.00	5.82
80	29.7	0.87	4.60	23.8	0.94	5.32	20.4	0.99	5.88
90	33.4	0.87	4.59	26.7	0.94	5.35	22.9	0.99	5.91
100	37.0	0.87	4.62	29.6	0.93	5.38	25.5	0.99	5.86
110	40.7	0.87	4.61	32.5	0.93	5.39	28.0	0.99	5.88
120	44.3	0.87	4.62	35.4	0.93	5.41	30.5	0.99	5.89
130	47.9	0.87	4.64	38.3	0.93	5.41	33.0	0.99	5.90
140	51.5	0.87	4.64	41.2	0.93	5.42	35.5	0.99	5.91
150	55.1	0.87	4.65	44.1	0.93	5.42	37.9	0.99	5.96
160	58.7	0.87	4.65	47.0	0.94	5.42	40.4	0.99	5.95
170	62.3	0.87	4.65	49.9	0.94	5.41	42.9	0.99	5.95
180	65.9	0.87	4.65	52.7	0.93	5.44	45.4	0.99	5.94
190	69.4	0.87	4.67	55.6	0.94	5.43	47.8	0.99	5.97
200	73.0	0.87	4.66	58.4	0.94	5.45	50.3	0.99	5.96
220	80.1	0.87	4.68	64.2	0.94	5.45	55.2	0.99	5.99
240	87.3	0.87	4.68	69.9	0.94	5.46	60.2	0.99	5.98
260	94.4	0.87	4.69	75.6	0.94	5.47	65.1	0.99	5.99
280	101.5	0.87	4.70	81.4	0.94	5.46	70.0	0.99	6.01
300	108.6	0.87	4.70	87.0	0.94	5.48	74.9	0.99	6.01

Parabolic waterway design
(Retardance "D" and "C")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "C".

Grade 6.0 Percent

Q cfs	V_1 = 2.0 T	D	V_2	V_1 = 2.5 T	D	V_2	V_1 = 3.0 T	D	V_2	V_1 = 3.5 T	D	V_2	V_1 = 4.0 T	D	V_2	V_1 = 4.5 T	D	V_2	V_1 = 5.0 T	D	V_2	V_1 = 5.5 T	D	V_2	V_1 = 6.0 T	D	V_2
15	34.6	0.53	1.22	22.6	0.57	1.72	16.6	0.61	2.20	12.6	0.65	2.68	10.0	0.70	3.15	8.1	0.76	3.59	6.6	0.82	4.05	5.3	0.90	4.61	4.3	0.98	5.19
20	46.0	0.53	1.22	30.0	0.57	1.73	22.1	0.61	2.20	16.8	0.66	2.68	13.2	0.69	3.25	10.7	0.74	3.71	8.7	0.80	4.22	7.0	0.88	4.79	5.7	0.96	5.36
25	57.2	0.52	1.23	37.4	0.57	1.74	27.6	0.61	2.20	21.0	0.66	2.68	16.5	0.69	3.25	13.3	0.73	3.78	10.8	0.79	4.32	8.7	0.86	4.90	7.0	0.92	5.69
30	68.5	0.53	1.23	44.7	0.57	1.75	33.0	0.61	2.22	25.1	0.66	2.70	19.8	0.69	3.24	16.0	0.74	3.75	13.0	0.80	4.29	10.4	0.86	4.97	8.4	0.92	5.71
35	79.6	0.53	1.24	52.0	0.57	1.76	38.4	0.61	2.22	29.2	0.65	2.71	23.0	0.69	3.28	18.6	0.74	3.78	15.1	0.79	4.34	12.1	0.85	5.01	9.8	0.92	5.72
40	90.6	0.52	1.24	59.3	0.57	1.76	43.8	0.61	2.22	33.3	0.65	2.72	26.3	0.69	3.26	21.2	0.74	3.80	17.2	0.79	4.37	13.8	0.85	5.04	11.2	0.92	5.72
45	101.6	0.53	1.25	66.5	0.57	1.76	49.1	0.61	2.24	37.4	0.66	2.72	29.5	0.69	3.28	23.8	0.73	3.81	19.4	0.79	4.33	15.5	0.85	5.05	12.5	0.91	5.85
50	112.5	0.53	1.25	73.6	0.57	1.77	54.4	0.61	2.24	41.5	0.66	2.72	32.7	0.69	3.29	26.4	0.74	3.82	21.5	0.79	4.35	17.2	0.85	5.06	13.9	0.91	5.83
55	123.3	0.53	1.25	80.8	0.57	1.77	59.7	0.61	2.25	45.5	0.66	2.73	35.9	0.69	3.29	29.0	0.74	3.82	23.6	0.79	4.37	18.8	0.84	5.15	15.3	0.92	5.82
60	134.1	0.53	1.26	87.8	0.57	1.78	65.0	0.61	2.25	49.5	0.66	2.74	39.1	0.69	3.30	31.6	0.74	3.82	25.7	0.79	4.38	20.5	0.84	5.14	16.6	0.91	5.90
65	144.7	0.53	1.26	94.9	0.57	1.78	70.2	0.61	2.26	53.5	0.66	2.75	42.2	0.69	3.32	34.1	0.73	3.85	27.8	0.79	4.38	22.2	0.85	5.14	18.0	0.91	5.87
70	155.3	0.53	1.27	101.9	0.57	1.79	75.4	0.61	2.26	57.5	0.66	2.75	45.4	0.69	3.31	36.7	0.74	3.84	29.9	0.79	4.39	23.9	0.85	5.13	19.3	0.91	5.94
75	165.8	0.53	1.27	108.8	0.57	1.80	80.6	0.61	2.26	61.5	0.66	2.75	48.5	0.69	3.33	39.2	0.73	3.86	31.9	0.79	4.43	25.5	0.84	5.18	20.7	0.91	5.91
80	176.3	0.53	1.27	115.7	0.57	1.80	85.8	0.61	2.27	65.4	0.66	2.76	51.7	0.69	3.32	41.8	0.74	3.85	34.0	0.79	4.42	27.2	0.85	5.16	22.0	0.91	5.96
90	197.6	0.53	1.28	129.8	0.57	1.80	96.2	0.61	2.28	73.4	0.66	2.77	58.0	0.69	3.33	46.9	0.74	3.87	38.2	0.79	4.43	30.5	0.84	5.20	24.8	0.91	5.91
100	218.8	0.53	1.28	143.8	0.57	1.81	106.6	0.61	2.28	81.4	0.66	2.77	64.3	0.69	3.34	52.0	0.74	3.88	42.4	0.79	4.42	33.9	0.85	5.18	27.5	0.91	5.93
110	239.9	0.53	1.28	157.7	0.57	1.81	117.0	0.61	2.28	89.3	0.66	2.78	70.6	0.69	3.35	57.1	0.74	3.88	46.5	0.79	4.45	37.2	0.84	5.20	30.2	0.91	5.95
120	260.8	0.53	1.29	171.5	0.57	1.82	127.3	0.61	2.29	97.2	0.66	2.79	76.9	0.69	3.35	62.2	0.74	3.89	50.7	0.79	4.44	40.5	0.84	5.22	32.9	0.91	5.96
130	281.5	0.53	1.29	185.3	0.57	1.82	137.6	0.61	2.29	105.1	0.66	2.79	83.1	0.69	3.36	67.2	0.74	3.90	54.8	0.79	4.46	43.8	0.84	5.23	35.6	0.91	5.96
140	302.1	0.53	1.30	199.0	0.57	1.83	147.8	0.61	2.30	112.9	0.66	2.80	89.3	0.69	3.36	72.3	0.74	3.90	58.9	0.79	4.46	47.1	0.84	5.24	38.3	0.91	5.97
150	322.6	0.53	1.30	212.6	0.57	1.83	157.9	0.61	2.30	120.7	0.66	2.80	95.5	0.69	3.37	77.3	0.74	3.91	63.0	0.79	4.47	50.4	0.84	5.24	40.9	0.91	6.01
160	342.9	0.53	1.30	226.1	0.57	1.84	168.0	0.61	2.31	128.5	0.66	2.80	101.7	0.69	3.37	82.3	0.74	3.91	67.1	0.79	4.47	53.7	0.85	5.24	43.6	0.91	6.00
170	363.1	0.53	1.31	239.6	0.57	1.84	178.0	0.61	2.32	136.2	0.66	2.81	107.8	0.69	3.37	87.3	0.74	3.91	71.2	0.79	4.47	56.9	0.84	5.27	46.3	0.91	5.99
180	383.1	0.53	1.31	253.0	0.57	1.84	188.0	0.61	2.32	143.9	0.66	2.81	113.9	0.69	3.38	92.2	0.74	3.93	75.2	0.79	4.49	60.2	0.85	5.26	48.9	0.91	6.02
190	403.0	0.53	1.32	266.3	0.57	1.85	197.9	0.61	2.33	151.5	0.66	2.82	120.0	0.70	3.38	97.1	0.74	3.94	79.3	0.79	4.49	63.4	0.84	5.28	51.6	0.91	6.01
200	422.7	0.53	1.32	279.5	0.57	1.85	207.8	0.61	2.33	159.1	0.66	2.82	126.1	0.70	3.39	102.1	0.74	3.93	83.3	0.79	4.50	66.7	0.85	5.27	54.2	0.91	6.03
220	463.4	0.53	1.32	306.6	0.57	1.86	228.0	0.61	2.33	174.6	0.66	2.83	138.4	0.70	3.39	112.0	0.74	3.95	91.5	0.79	4.50	73.2	0.85	5.29	59.6	0.91	6.02
240	503.8	0.53	1.33	333.6	0.57	1.86	248.1	0.61	2.34	190.1	0.66	2.83	150.7	0.70	3.40	122.0	0.74	3.95	99.7	0.80	4.50	79.8	0.85	5.28	64.9	0.91	6.04
260	543.8	0.53	1.33	360.4	0.57	1.86	268.1	0.61	2.34	205.4	0.66	2.84	162.9	0.70	3.40	131.9	0.74	3.96	107.8	0.80	4.51	86.3	0.85	5.29	70.2	0.91	6.05
280	583.6	0.53	1.34	387.0	0.57	1.87	287.9	0.61	2.35	220.7	0.66	2.85	175.1	0.70	3.41	141.8	0.74	3.96	115.9	0.80	4.51	92.8	0.85	5.30	75.5	0.91	6.05
300	623.2	0.53	1.34	413.5	0.58	1.87	307.7	0.61	2.36	235.9	0.66	2.85	187.2	0.70	3.41	151.6	0.74	3.97	123.9	0.80	4.53	99.3	0.85	5.30	80.8	0.91	6.06

Parabolic waterway design
(Retardance "D" and "C")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "C".

Grade 8.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	37.0	0.47	1.26	26.6	0.51	1.65	18.7	0.54	2.19	15.3	0.57	2.54	11.7	0.61	3.08	9.4	0.65	3.61	7.9	0.70	3.99	6.4	0.74	4.62	5.3	0.80	5.18
20	49.2	0.47	1.26	35.3	0.50	1.66	24.9	0.54	2.19	20.4	0.57	2.54	15.6	0.61	3.08	12.5	0.65	3.65	10.4	0.68	4.17	8.5	0.74	4.70	7.1	0.80	5.16
25	61.2	0.47	1.27	44.0	0.50	1.67	31.0	0.54	2.21	25.4	0.57	2.56	19.4	0.61	3.12	15.6	0.65	3.67	13.0	0.68	4.17	10.6	0.73	4.75	8.8	0.79	5.32
30	73.2	0.47	1.28	52.6	0.50	1.67	37.2	0.54	2.19	30.4	0.57	2.57	23.3	0.61	3.10	18.7	0.65	3.67	15.6	0.68	4.17	12.7	0.73	4.77	10.5	0.78	5.41
35	85.1	0.47	1.28	61.2	0.50	1.68	43.2	0.54	2.21	35.3	0.57	2.59	27.1	0.61	3.12	21.7	0.64	3.72	18.1	0.68	4.23	14.8	0.73	4.78	12.2	0.77	5.48
40	96.9	0.47	1.28	69.7	0.50	1.68	49.3	0.54	2.21	40.3	0.57	2.59	30.9	0.61	3.13	24.8	0.64	3.71	20.7	0.68	4.20	16.9	0.73	4.78	13.9	0.77	5.53
45	108.6	0.47	1.29	78.2	0.51	1.68	55.3	0.54	2.22	45.2	0.57	2.60	34.6	0.61	3.16	27.8	0.64	3.73	23.2	0.68	4.24	19.0	0.73	4.78	15.7	0.78	5.45
50	120.2	0.48	1.29	86.5	0.50	1.69	61.2	0.54	2.23	50.0	0.57	2.62	38.4	0.61	3.15	30.9	0.65	3.71	25.8	0.68	4.21	21.0	0.73	4.84	17.4	0.78	5.48
55	131.8	0.48	1.30	94.9	0.51	1.70	67.1	0.54	2.24	54.9	0.57	2.62	42.1	0.61	3.17	33.9	0.65	3.73	28.3	0.68	4.23	23.1	0.73	4.83	19.1	0.78	5.50
60	143.2	0.48	1.30	103.1	0.51	1.70	73.0	0.54	2.24	59.7	0.57	2.62	45.9	0.61	3.16	36.9	0.65	3.73	30.8	0.68	4.24	25.1	0.73	4.87	20.8	0.78	5.51
65	154.6	0.48	1.30	111.4	0.51	1.71	78.9	0.54	2.24	64.5	0.57	2.63	49.6	0.61	3.16	39.9	0.65	3.74	33.3	0.68	4.25	27.2	0.73	4.85	22.5	0.78	5.52
70	165.9	0.48	1.31	119.5	0.51	1.71	84.7	0.54	2.25	69.3	0.57	2.63	53.2	0.61	3.19	42.8	0.64	3.76	35.8	0.68	4.26	29.2	0.73	4.88	24.1	0.77	5.59
75	177.1	0.48	1.31	127.6	0.51	1.72	90.5	0.54	2.25	74.1	0.57	2.63	56.9	0.61	3.19	45.8	0.65	3.76	38.2	0.68	4.29	31.2	0.73	4.90	25.8	0.77	5.59
80	188.2	0.48	1.32	135.6	0.51	1.72	96.2	0.54	2.26	78.8	0.57	2.64	60.5	0.61	3.20	48.7	0.64	3.78	40.7	0.68	4.29	33.3	0.73	4.87	27.5	0.77	5.58
90	210.9	0.48	1.32	152.1	0.51	1.73	108.0	0.55	2.26	88.4	0.57	2.65	67.9	0.61	3.21	54.7	0.65	3.78	45.7	0.68	4.29	37.4	0.73	4.88	30.9	0.77	5.59
100	233.5	0.48	1.32	168.4	0.51	1.73	119.6	0.55	2.27	98.0	0.57	2.65	75.3	0.61	3.21	60.7	0.65	3.78	50.6	0.68	4.32	41.4	0.73	4.92	34.2	0.77	5.64
110	255.9	0.48	1.33	184.6	0.51	1.74	131.2	0.55	2.28	107.5	0.57	2.66	82.6	0.61	3.22	66.6	0.65	3.79	55.6	0.68	4.32	45.5	0.73	4.91	37.6	0.77	5.63
120	278.1	0.48	1.33	200.7	0.51	1.74	142.7	0.55	2.28	116.9	0.57	2.67	89.9	0.61	3.22	72.5	0.65	3.79	60.5	0.68	4.33	49.5	0.73	4.93	40.9	0.77	5.66
130	300.2	0.48	1.34	216.6	0.51	1.75	154.1	0.55	2.29	126.4	0.57	2.67	97.1	0.61	3.24	78.3	0.65	3.81	65.4	0.68	4.34	53.6	0.73	4.92	44.3	0.77	5.64
140	322.1	0.48	1.34	232.5	0.51	1.76	165.5	0.55	2.29	135.7	0.57	2.67	104.4	0.62	3.23	84.2	0.65	3.81	70.3	0.68	4.34	57.6	0.73	4.93	47.6	0.77	5.66
150	343.9	0.48	1.34	248.3	0.51	1.76	176.8	0.55	2.30	145.0	0.57	2.68	111.5	0.61	3.25	90.0	0.65	3.82	75.2	0.68	4.35	61.6	0.73	4.94	50.9	0.77	5.67
160	365.5	0.48	1.35	264.0	0.51	1.76	188.1	0.55	2.30	154.3	0.57	2.68	118.7	0.62	3.25	95.8	0.65	3.82	80.0	0.68	4.36	65.6	0.73	4.94	54.2	0.77	5.68
170	386.9	0.48	1.35	279.6	0.51	1.77	199.3	0.55	2.31	163.5	0.57	2.69	125.8	0.62	3.26	101.6	0.65	3.82	84.8	0.68	4.37	69.5	0.73	4.97	57.5	0.77	5.69
180	408.2	0.48	1.36	295.1	0.51	1.77	210.4	0.55	2.31	172.7	0.57	2.69	132.8	0.62	3.27	107.3	0.65	3.84	89.7	0.68	4.36	73.5	0.73	4.96	60.8	0.77	5.69
190	429.3	0.48	1.36	310.5	0.51	1.78	221.4	0.55	2.32	181.8	0.57	2.70	139.9	0.62	3.27	113.0	0.65	3.84	94.4	0.68	4.38	77.4	0.73	4.98	64.0	0.77	5.71
200	450.2	0.48	1.36	325.7	0.51	1.78	232.4	0.55	2.32	190.8	0.57	2.71	146.9	0.62	3.28	118.7	0.65	3.85	99.2	0.68	4.39	81.4	0.73	4.97	67.3	0.77	5.71
220	493.4	0.48	1.37	357.1	0.51	1.79	254.9	0.55	2.33	209.4	0.58	2.71	161.1	0.62	3.29	130.3	0.65	3.85	108.9	0.68	4.39	89.3	0.73	4.99	73.9	0.77	5.72
240	536.2	0.48	1.37	388.3	0.51	1.79	277.3	0.55	2.34	227.8	0.58	2.71	175.4	0.62	3.29	141.8	0.65	3.86	118.6	0.68	4.40	97.3	0.74	4.99	80.5	0.77	5.72
260	578.8	0.48	1.38	419.3	0.51	1.80	299.5	0.55	2.34	246.2	0.58	2.72	189.5	0.62	3.30	153.3	0.65	3.87	128.2	0.68	4.40	105.2	0.74	5.00	87.0	0.77	5.74
280	621.1	0.48	1.38	450.1	0.51	1.80	321.6	0.55	2.35	264.4	0.58	2.72	203.6	0.62	3.31	164.8	0.65	3.87	137.8	0.68	4.41	113.1	0.74	5.00	93.5	0.77	5.76
300	663.1	0.48	1.39	480.7	0.51	1.81	343.6	0.55	2.35	282.6	0.58	2.73	217.6	0.62	3.31	176.1	0.65	3.88	147.4	0.69	4.41	120.9	0.74	5.02	100.1	0.78	5.75

Parabolic waterway design
(Retardance "D" and "C")

4-26467 5-68

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "C".

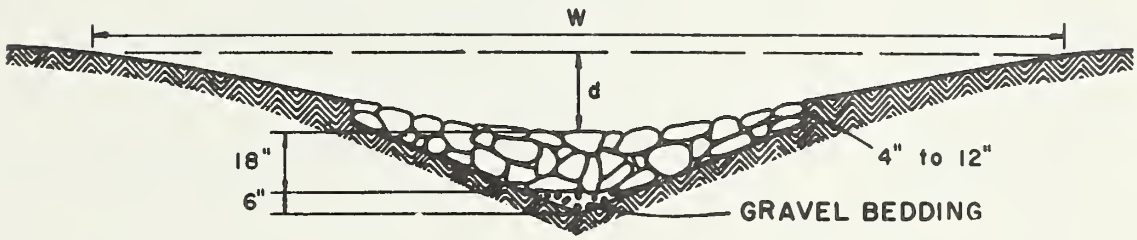
Grade 10.0 Percent

Q cfs	V_1 = 2.0 T	D	V_2	V_1 = 2.5 T	D	V_2	V_1 = 3.0 T	D	V_2	V_1 = 3.5 T	D	V_2	V_1 = 4.0 T	D	V_2	V_1 = 4.5 T	D	V_2	V_1 = 5.0 T	D	V_2	V_1 = 5.5 T	D	V_2	V_1 = 6.0 T	D	V_2
15	45.2	0.43	1.14	32.5	0.45	1.50	22.9	0.49	1.98	16.6	0.52	2.56	13.4	0.55	2.99	10.7	0.58	3.55	9.0	0.61	3.99	7.4	0.65	4.57	6.2	0.70	5.08
20	60.1	0.43	1.14	43.2	0.45	1.50	30.4	0.49	2.00	22.1	0.52	2.56	17.8	0.55	3.02	14.3	0.59	3.52	12.0	0.61	4.00	9.9	0.65	4.55	8.3	0.70	5.06
25	74.8	0.43	1.15	53.8	0.45	1.51	37.9	0.49	2.00	27.5	0.52	2.59	22.3	0.55	2.99	17.8	0.58	3.56	14.9	0.61	4.08	12.3	0.65	4.63	10.3	0.69	5.18
30	89.3	0.43	1.15	64.2	0.45	1.52	45.3	0.49	2.01	33.0	0.52	2.58	26.6	0.55	3.03	21.3	0.58	3.58	17.9	0.61	4.05	14.7	0.64	4.68	12.4	0.70	5.13
35	103.7	0.43	1.16	74.6	0.45	1.53	52.6	0.48	2.03	38.3	0.52	2.60	31.0	0.55	3.02	24.8	0.58	3.59	20.8	0.61	4.09	17.2	0.65	4.63	14.4	0.69	5.19
40	118.0	0.43	1.16	85.0	0.46	1.53	59.9	0.48	2.04	43.7	0.52	2.60	35.3	0.55	3.04	28.3	0.58	3.59	23.8	0.61	4.06	19.6	0.65	4.66	16.4	0.69	5.24
45	132.2	0.43	1.17	95.2	0.45	1.53	67.2	0.49	2.04	49.0	0.52	2.61	39.6	0.55	3.05	31.7	0.58	3.62	26.7	0.61	4.08	22.0	0.65	4.68	18.4	0.69	5.27
50	146.3	0.43	1.17	105.3	0.45	1.54	74.4	0.49	2.04	54.3	0.52	2.61	43.9	0.55	3.05	35.2	0.58	3.61	29.6	0.61	4.09	24.4	0.65	4.68	20.4	0.69	5.28
55	160.2	0.43	1.17	115.4	0.46	1.55	81.5	0.49	2.06	59.5	0.52	2.63	48.2	0.55	3.05	38.6	0.58	3.62	32.4	0.61	4.13	26.7	0.64	4.74	22.4	0.69	5.29
60	174.0	0.43	1.18	125.3	0.46	1.55	88.6	0.49	2.06	64.7	0.52	2.63	52.4	0.55	3.07	42.0	0.58	3.63	35.3	0.61	4.12	29.1	0.65	4.73	24.4	0.69	5.30
65	187.6	0.43	1.18	135.2	0.46	1.56	95.6	0.49	2.07	69.9	0.52	2.64	56.6	0.55	3.08	45.4	0.58	3.64	38.2	0.61	4.12	31.5	0.65	4.72	26.4	0.69	5.30
70	201.2	0.43	1.19	145.0	0.46	1.57	102.6	0.49	2.08	75.1	0.52	2.64	60.8	0.55	3.08	48.7	0.58	3.66	41.0	0.61	4.14	33.8	0.65	4.75	28.4	0.69	5.29
75	214.6	0.43	1.19	154.7	0.46	1.57	109.6	0.49	2.08	80.2	0.52	2.65	65.0	0.55	3.08	52.1	0.58	3.66	43.8	0.61	4.15	36.2	0.65	4.74	30.3	0.69	5.34
80	227.9	0.43	1.20	164.3	0.46	1.58	116.4	0.49	2.09	85.3	0.52	2.65	69.1	0.55	3.09	55.4	0.58	3.67	46.6	0.61	4.16	38.5	0.65	4.76	32.3	0.69	5.33
90	255.2	0.43	1.20	184.1	0.46	1.58	130.5	0.49	2.10	95.6	0.52	2.67	77.5	0.55	3.11	62.1	0.58	3.69	52.3	0.61	4.17	43.2	0.65	4.78	36.3	0.69	5.33
100	282.4	0.43	1.20	203.7	0.46	1.59	144.5	0.49	2.10	105.9	0.52	2.67	85.9	0.56	3.11	68.8	0.58	3.70	58.0	0.61	4.18	47.9	0.65	4.78	40.2	0.69	5.36
110	309.2	0.43	1.21	223.2	0.46	1.60	158.4	0.49	2.11	116.2	0.52	2.68	94.3	0.56	3.11	75.5	0.58	3.71	63.7	0.61	4.18	52.6	0.65	4.79	44.2	0.69	5.34
120	335.9	0.43	1.21	242.4	0.46	1.60	172.2	0.49	2.12	126.4	0.52	2.68	102.5	0.56	3.12	82.2	0.58	3.71	69.3	0.61	4.19	57.3	0.65	4.79	48.1	0.69	5.36
130	362.3	0.43	1.22	261.6	0.46	1.61	185.9	0.49	2.12	136.5	0.52	2.69	110.8	0.56	3.13	88.8	0.58	3.72	74.9	0.61	4.20	61.9	0.65	4.81	52.0	0.69	5.37
140	388.4	0.44	1.22	280.5	0.46	1.61	199.5	0.49	2.13	146.5	0.52	2.70	119.0	0.56	3.13	95.4	0.58	3.73	80.5	0.61	4.20	66.5	0.65	4.82	55.9	0.69	5.38
150	414.4	0.44	1.23	299.3	0.46	1.62	213.0	0.49	2.13	156.5	0.52	2.71	127.1	0.56	3.14	101.9	0.58	3.74	86.0	0.61	4.22	71.1	0.65	4.83	59.7	0.69	5.41
160	440.1	0.44	1.23	318.1	0.46	1.62	226.5	0.49	2.14	166.4	0.53	2.71	135.2	0.56	3.15	108.4	0.58	3.75	91.6	0.62	4.21	75.7	0.65	4.83	63.6	0.69	5.41
170	465.5	0.44	1.24	336.7	0.46	1.63	239.8	0.49	2.14	176.3	0.53	2.72	143.3	0.56	3.15	114.9	0.58	3.76	97.1	0.62	4.22	80.3	0.65	4.83	67.4	0.69	5.42
180	490.8	0.44	1.24	355.1	0.46	1.63	253.1	0.49	2.15	186.1	0.53	2.73	151.3	0.56	3.16	121.3	0.58	3.77	102.5	0.62	4.24	84.9	0.65	4.83	71.3	0.69	5.42
190	515.7	0.44	1.25	373.5	0.46	1.64	266.3	0.49	2.15	195.9	0.53	2.73	159.3	0.56	3.17	127.7	0.58	3.78	108.0	0.62	4.24	89.4	0.65	4.84	75.1	0.69	5.43
200	540.5	0.44	1.25	391.6	0.46	1.64	279.4	0.49	2.16	205.6	0.53	2.74	167.2	0.56	3.17	134.1	0.58	3.79	113.4	0.62	4.25	93.9	0.65	4.85	78.9	0.69	5.43
220	592.0	0.44	1.26	429.2	0.46	1.65	306.3	0.49	2.17	225.4	0.53	2.75	183.5	0.56	3.18	147.1	0.58	3.80	124.4	0.62	4.26	103.1	0.65	4.85	86.6	0.69	5.45
240	643.0	0.44	1.26	466.4	0.46	1.65	333.1	0.49	2.17	245.2	0.53	2.75	199.6	0.56	3.19	160.0	0.58	3.81	135.4	0.62	4.27	112.2	0.65	4.87	94.3	0.69	5.45
260	693.6	0.44	1.27	503.4	0.46	1.66	359.6	0.49	2.18	264.8	0.53	2.76	215.6	0.56	3.19	172.9	0.58	3.82	146.4	0.62	4.27	121.3	0.65	4.87	101.9	0.69	5.47
280	743.7	0.44	1.27	540.0	0.46	1.66	386.0	0.49	2.18	284.4	0.53	2.77	231.6	0.56	3.20	185.8	0.59	3.82	157.3	0.62	4.28	130.4	0.65	4.88	109.6	0.69	5.47
300	793.4	0.44	1.28	576.4	0.46	1.67	412.3	0.49	2.19	303.8	0.53	2.77	247.5	0.56	3.21	198.6	0.59	3.83	168.1	0.62	4.29	139.4	0.65	4.89	117.2	0.69	5.48

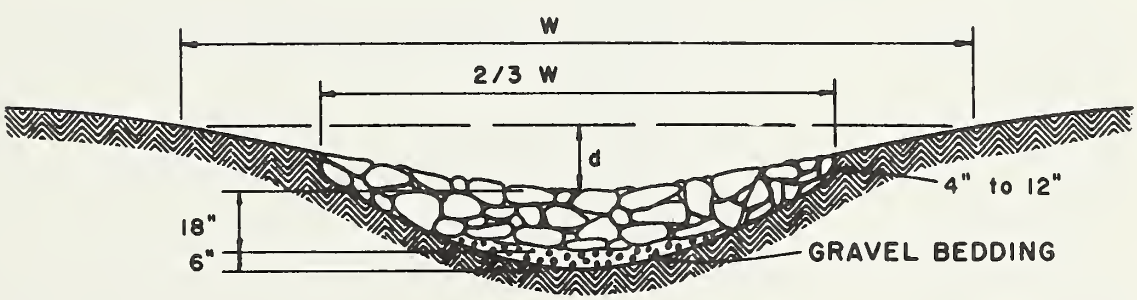
Parabolic waterway design
(Retardance "D" and "C")

4-26467 5-68

STONE CENTERED WATERWAY



Waterway with stone center drain
V section shaped by motor patrol



Waterway with stone center drain
Rounded section shaped by bulldozer

Waterway with stone center

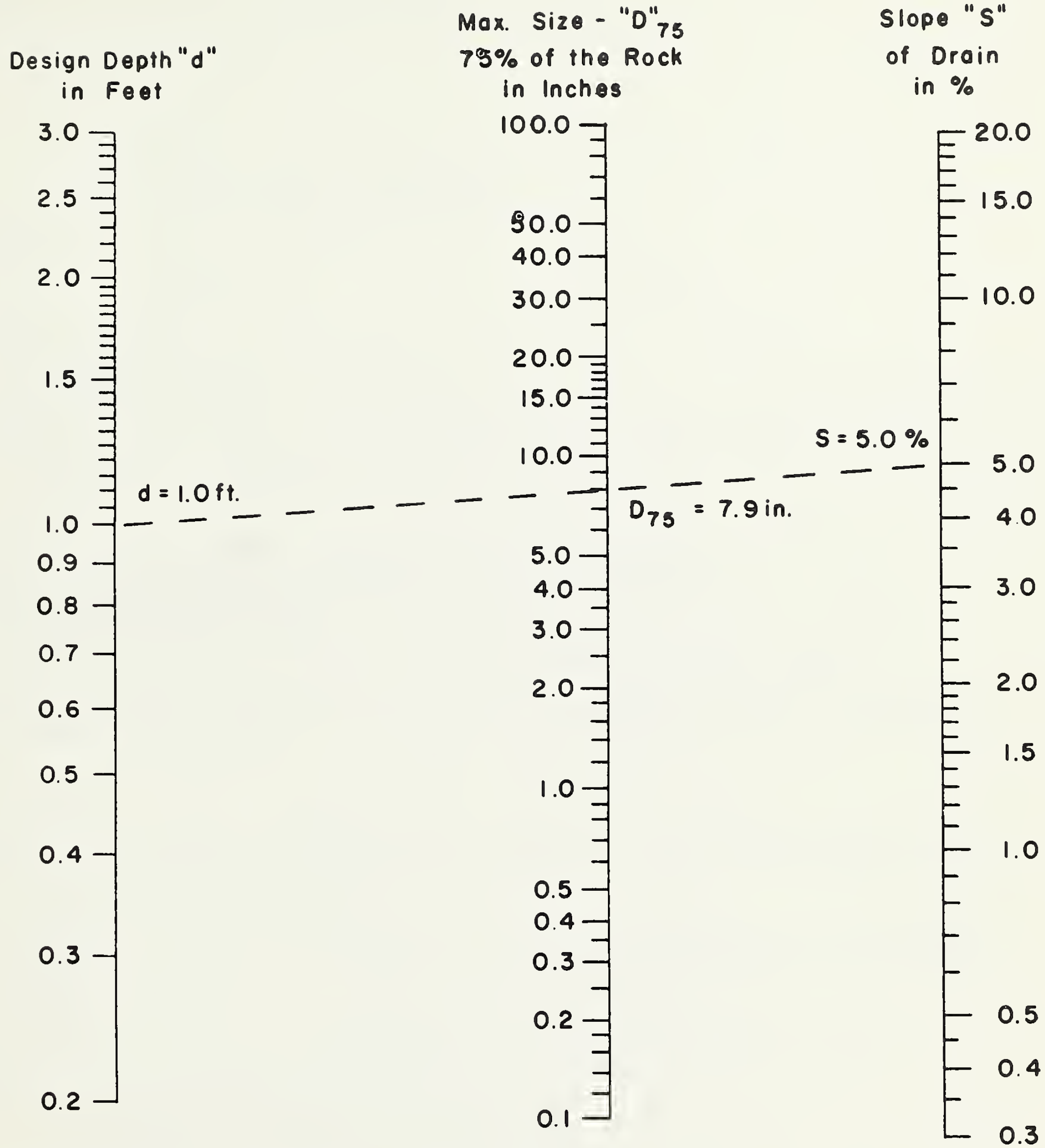
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE 11-68 4-L-27908

PARABOLIC STONE CENTER WATERWAY

Velocity, Top Width and Depth Based on Retardance "C"

	Grade 6 Percent		Grade 8 Percent		Grade 10 Percent		Grade 12 Percent		Grade 15 Percent	
V	8.0	10	8.0	10.0	8.0	10.0	8.0	10.0	8.0	10.0
D	1.3	1.6	1.1	1.3	1.0	1.2	0.9	1.1	0.8	0.9
Q					Top Widths					
20							5		5	
25					5		6		6	4
30			5		6		7		7	5
35			6		7		8	5	8	6
40	6		7		8	5	9	6	10	7
45	7		8		9	6	10	6	11	7
50	7		9	6	10	7	11	7	12	8
55	8		9	6	11	7	12	8	13	9
60	9		10	7	12	8	13	8	14	9
65	9		11	7	12	9	14	9	16	11
70	10	7	12	8	13	9	15	10	17	11
75	11	7	13	9	14	10	16	10	18	12
80	12	8	14	9	15	10	18	11	19	13
90	13	9	15	10	17	12	20	13	21	15
100	14	10	17	11	19	13	22	14	24	16
110	16	11	19	13	21	14	24	15	26	18
120	17	11	21	14	23	16	26	17	29	20
130	19	12	22	15	25	17	29	18	31	21
140	20	13	24	16	27	18	31	19	33	23
150	22	14	26	17	29	20	33	21	36	24
160	23	15	27	18	31	21	35	22	38	26
170	25	16	29	19	33	22	37	24	40	28
180	26	17	31	20	34	23	39	25	43	29
190	27	18	32	22	36	25	42	26	45	31
200	29	19	34	23	38	26	44	28	47	33
220	32	21	38	25	42	29	48	31	52	38
240	35	23	41	27	46	31	53	33	57	39
260	38	25	44	30	50	34	57	36	62	42
280	40	27	48	32	54	36	61	39	67	45
300	43	29	51	34	57	39	66	42	71	49

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE



EXAMPLE: "d" = 1.0 Feet "S" = 5 %

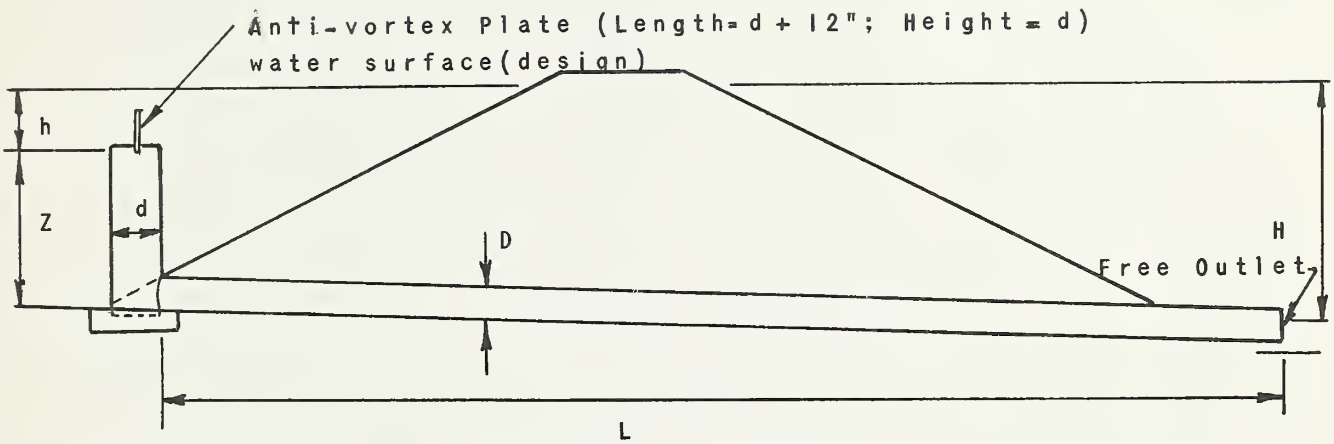
Place straight edge at "d" value in Design Depth column and at "S" value in Slope column. Read rock size in middle column 7.9 inches. Say 8 inches.

FOR DESIGN:

25 % of the rock by volume should be in sizes of 8 inches or slightly larger. The remaining 75 % or less should be of well graded material, smaller than 8 inches, including sufficient sands and gravels to fill the voids between the larger rock.

Determination of rock size for stone center waterway

PIPE SPILLWAY DESIGN



H = Head operating pipe spillway (pipe flow) ft.
h = Head operating inlet riser (water flow) ft. h = 1' min
L = Length of pipe in ft.
D = Diameter of pipe conduit; d = diameter of pipe riser

Spillway discharge capacities should be reduced 40% if no anti-vortex device is used.

To use charts:

Enter chart Page B-5.2 or B-5.3 with H. Read discharge under diameter of pipe conduit.

Enter chart Page B-5.4 with h. Read discharge under diameter of riser.

Spillway discharge Q = smaller of value obtained above.

Example

Given: D = 12" CMP with 15" CMP Riser
L = 60'
H = 9' to ℄ pipe - Free outlet
h = 1.0'
Find Q of spillway from Page B-5.2 and Page B-5.4
Qpipe = 6.0 cfs x (correction factor) 1.07 = 6.4 cfs
Qriser = 12.2 cfs
Qspillway = 6.4 cfs

PIPE FLOW CHART (Full flow assumed)

For Corrugated Metal Pipe Inlet $K_e + K_b = 1.0$ and 70 feet of Corrugated Metal Pipe Conduit n = 0.025. Note correction factors for other pipe lengths.

Dia. / H	12"	15"	18"	21"	24"	30"	36"	42"
2	2.84	4.92	7.73	11.30	15.60	26.60	40.77	58.12
3	3.48	6.03	9.47	13.84	19.10	32.58	49.93	71.19
4	4.02	6.96	10.94	15.98	22.06	37.62	57.66	82.20
5	4.49	7.78	12.23	17.87	24.66	42.06	64.46	91.90
6	4.92	8.52	13.40	19.57	27.01	46.07	70.60	100.65
7	5.32	9.21	14.47	21.14	29.19	49.77	76.28	108.75
8	5.68	9.84	15.47	22.60	31.19	53.19	81.53	116.23
9	6.03	10.44	16.41	23.97	33.09	56.43	86.49	123.30
10	6.36	11.00	17.30	25.26	34.88	59.48	91.16	129.96
11	6.67	11.54	18.14	26.50	36.59	62.39	95.63	136.33
12	6.96	12.05	18.95	27.68	38.21	65.16	99.87	142.37
13	7.25	12.55	19.72	28.81	39.77	67.83	103.96	148.21
14	7.52	13.02	20.47	29.90	41.27	70.39	107.88	153.80
15	7.78	13.48	21.19	30.95	42.72	72.85	111.66	159.18
16	8.04	13.92	21.88	31.96	44.12	75.24	115.32	164.40
17	8.29	14.35	22.55	32.94	45.48	77.55	118.87	169.46
18	8.53	14.77	23.21	33.90	46.80	79.81	122.33	174.39
19	8.76	15.17	23.84	34.83	48.08	81.99	125.67	179.15
20	8.99	15.56	24.46	35.73	49.33	84.12	128.93	183.80
21	9.21	15.95	25.07	36.62	50.55	86.21	132.13	188.36
22	9.43	16.32	25.65	37.47	51.73	88.22	135.21	192.76
23	9.64	16.69	26.23	38.32	52.90	90.21	138.27	197.12
24	9.85	17.05	26.80	39.14	54.04	92.15	141.24	201.35
25	10.05	17.40	27.35	39.95	55.15	94.05	144.15	205.50
L	Correction Factors For Other Pipe Lengths							
40	1.23	1.22	1.20	1.19	1.16	1.14	1.13	1.11
50	1.14	1.13	1.12	1.11	1.10	1.09	1.08	1.07
60	1.07	1.06	1.06	1.05	1.05	1.04	1.04	1.03
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	0.95	0.95	0.95	0.96	0.96	0.96	0.97	0.97
90	0.90	0.91	0.91	0.92	0.92	0.93	0.94	0.94
100	0.86	0.87	0.88	0.89	0.89	0.90	0.91	0.92

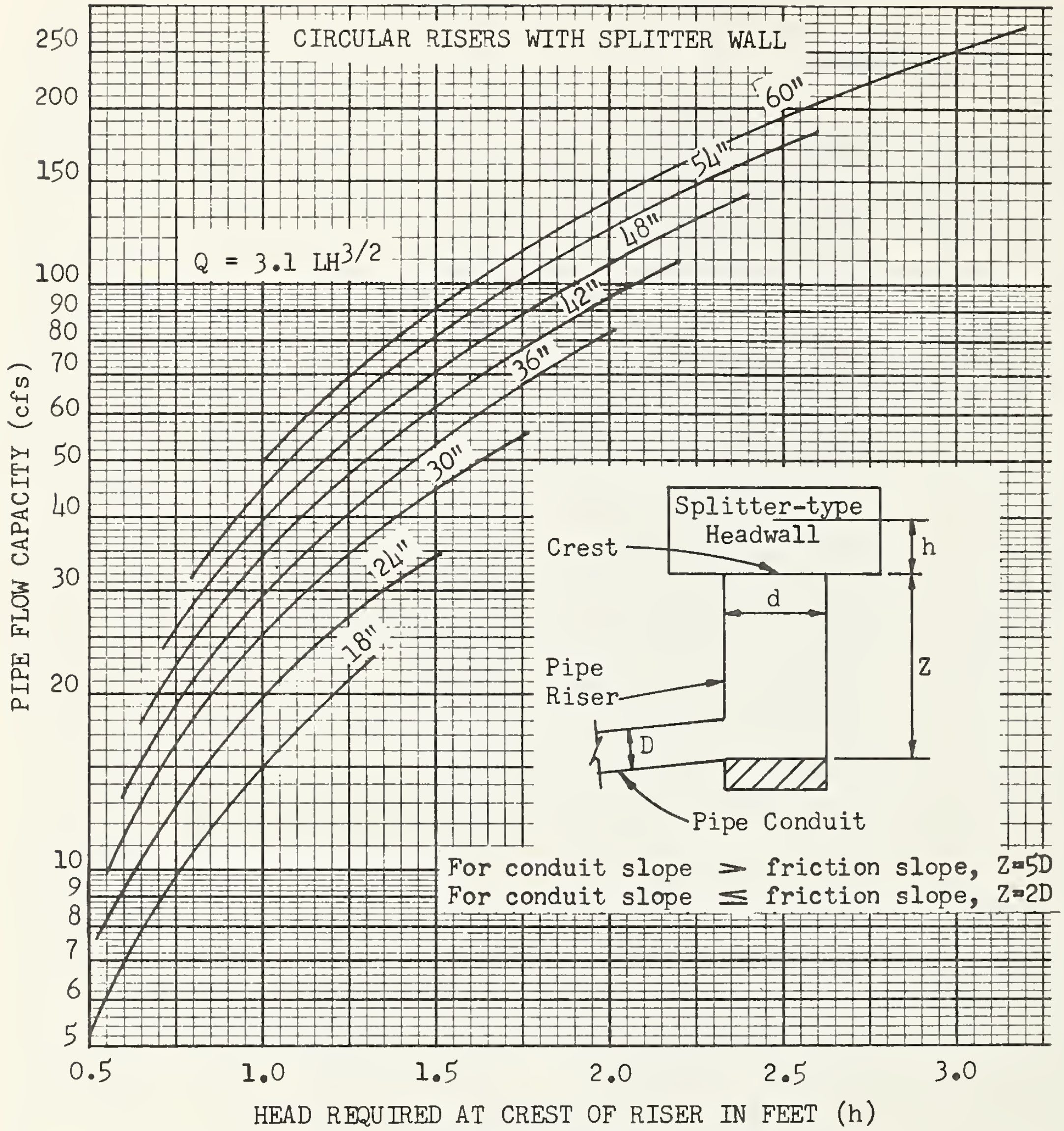
Pipe flow chart for corrugated metal pipe drop inlet spillway

PIPE FLOW CHART (Full Pipe flow assumed)

For R/C Drop Inlet, $K_e + K_b = 0.65$ with 70 feet of R/C conduit, n = .013. Note correction factors for other pipe lengths.

Dia. / H	12"	15"	18"	21"	24"	30"	36"	42"
2	4.54	8.01	11.74	16.60	22.44	36.74	54.65	76.02
3	5.56	9.81	14.39	20.33	27.49	45.00	66.94	93.11
4	6.42	11.33	16.61	23.48	31.74	51.96	77.30	107.52
5	7.18	12.66	18.57	26.25	35.49	58.09	86.42	120.21
6	7.87	13.86	20.34	28.75	38.87	63.63	94.65	131.66
7	8.50	14.98	21.98	31.06	41.99	68.74	102.27	142.25
8	9.08	16.01	23.49	33.20	44.88	73.47	109.30	152.03
9	9.64	17.00	24.92	35.22	47.61	77.94	115.95	161.28
10	10.16	17.91	26.26	37.12	50.18	82.15	122.21	169.99
11	10.65	18.78	27.55	38.94	52.64	86.18	128.20	178.32
12	11.13	19.62	28.77	40.67	54.97	89.99	133.88	186.22
13	11.58	20.42	29.95	42.33	57.23	93.68	139.37	193.86
14	12.01	21.18	31.07	43.93	59.37	97.19	144.59	201.12
15	12.44	21.93	32.17	45.47	61.46	100.62	149.69	208.21
16	12.85	22.65	33.22	46.96	63.48	103.92	154.60	215.04
17	13.24	23.35	34.24	48.40	65.43	107.12	159.35	221.65
18	13.63	24.03	35.24	49.81	67.34	110.23	163.99	228.10
19	14.00	24.68	36.21	51.17	69.18	113.25	168.48	234.34
20	14.36	25.32	37.14	52.50	70.97	116.18	172.84	240.41
21	14.72	25.95	38.07	53.80	72.73	119.07	177.13	246.38
22	15.06	26.56	38.96	55.06	74.43	121.85	181.27	252.13
23	15.40	27.16	39.84	56.31	76.11	124.60	185.36	257.83
24	15.73	27.74	40.69	57.51	77.75	127.28	189.35	263.37
25	16.06	28.32	41.53	58.70	79.35	129.90	193.25	268.80
L	Correction Factors For Other Pipe Lengths							
40	1.15	1.13	1.11	1.09	1.08	1.06	1.06	1.05
50	1.09	1.08	1.07	1.06	1.05	1.04	1.04	1.03
60	1.04	1.04	1.04	1.03	1.03	1.02	1.02	1.02
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	0.96	0.96	0.97	0.97	0.98	0.98	0.98	0.99
90	0.93	0.94	0.94	0.95	0.95	0.96	0.97	0.97
100	0.90	0.91	0.92	0.93	0.93	0.95	0.95	0.96

Pipe flow chart for concrete
pipe drop inlet spillway



<u>Pipe Drop Inlet Spillway Design:</u>

Inlet Proportions	
Pipe Conduit (D)-in.	Pipe Riser (d)-in.
8-12	18
15	21
18	24
21	30
24	30
30	36
36	48
42	54
48	60

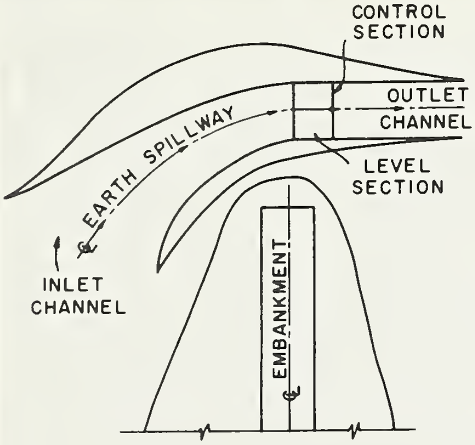
For a given Q and H, refer to B-5.2 or B-5.3 for conduit size. Then determine the riser diameter (d) from the Inlet Proportions table.

Next, refer to the above curves, using the conduit capacity and riser diameter and find the head (h) required above the crest of the riser. The height of the riser should not be less than 5D - h, except as noted in the above sketch.

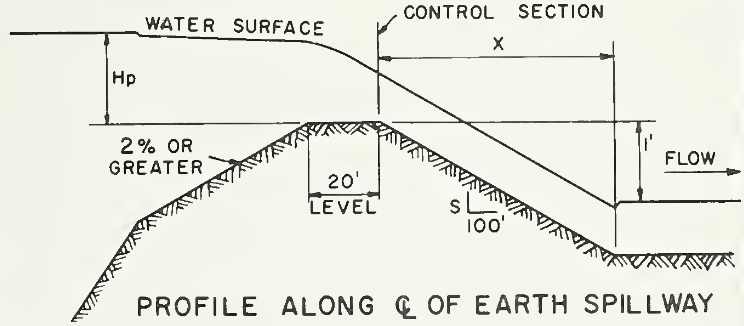
Example - Given: CMP; Q = 20 cfs; H = 14 ft.; L = 70 ft. From Figure 6-25 find conduit size (D) = 18 inches. From Inlet Proportions table, riser size = 24 inches. Head (h) required for Q = 20 and d = 30 is 1.0 foot.

Chart for determining inlet proportions
and required head over inlet

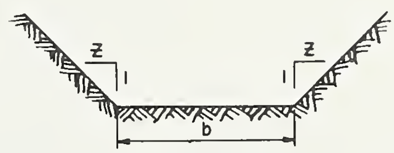
DESIGN DATA FOR EARTH SPILLWAYS



PLAN OF EARTH SPILLWAY



PROFILE ALONG ℄ OF EARTH SPILLWAY



CROSS SECTION OF EARTH SPILLWAY AT CONTROL SECTION

LEGEND

n	Manning's Coefficient of Roughness.
Hp	Difference in Elevation between Crest of Earth Spillway at the Control Section and Water Surface in Reservoir, in Feet.
b	Bottom Width of Earth Spillway at the Control Section, in Feet.
Q	Total Discharge, in cfs.
V	Velocity, in Feet Per Second, that will exist in Channel below Control Section, at Design Q, if Constructed to Slope (S) that is shown.
S	Flattest Slope (S), in %, allowable for Channel below Control Section.
X	Minimum Length of Channel below Control Section, in Feet.
Z	Side Slope Ratio

INDEX			
SIDE SLOPE RATIO (Z)	COVER	COEFFICIENT OF ROUGHNESS	SHEET
4:1	VEGETATED	n = 0.040	2
3:1	VEGETATED	n = 0.040	3

NOTE: DATA TO RIGHT OF HEAVY VERTICAL LINES ON DRAWINGS SHOULD BE USED WITH CAUTION, AS THE RESULTING SECTIONS WILL BE EITHER POORLY PROPORTIONED OR HAVE VELOCITIES IN EXCESS OF 6 FT. / SEC.

DESIGN DATA FOR EARTH SPILLWAYS

APRIL 1972
APPENDIX B-5

SIDE SLOPE 4:1

VEGETATED n=0.040

STAGE (Hp) IN FEET	SPILLWAY VARIABLES	BOTTOM WIDTH (b) IN FEET																
		8	16	12	16	16	16	20	22	28	28	28	30	32	34	36	38	40
0.5	Q	7	8	9	10	12	14	16	18	19	21	23	25	26	28	29	30	32
	V	2.6	2.6	2.6	2.6	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	S	4.0	4.0	3.9	3.8	3.9	3.8	3.9	3.8	3.8	3.8	3.8	3.9	3.8	3.8	3.6	3.8	3.8
	X	32	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
0.5	Q	9	11	12	14	17	19	21	23	25	28	30	32	34	36	38	40	41
	V	2.9	2.9	2.9	2.9	2.9	3.0	3.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	S	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.8	3.6	3.6	3.6	3.6	3.6	3.6	3.8	3.6
	X	36	36	36	36	36	37	37	37	37	37	37	37	37	37	37	37	37
0.7	Q	11	14	16	19	21	24	26	29	31	34	37	39	43	44	47	50	52
	V	3.2	3.2	3.2	3.2	3.2	3.2	3.9	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
	S	3.9	3.9	3.5	3.5	3.5	3.5	3.9	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.8	3.4	3.4
	X	40	40	40	40	41	41	41	41	41	41	41	41	41	41	41	41	41
0.8	Q	14	17	20	23	26	30	32	35	38	42	45	48	52	54	97	61	64
	V	3.8	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.8	3.6	3.8	3.8	3.8	3.9	3.6	3.6	3.6
	S	3.9	3.3	3.9	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
	X	44	44	44	44	45	45	45	49	45	45	49	49	45	45	49	45	45
0.5	Q	19	22	25	27	32	36	40	45	49	51	55	59	64	68	71	75	75
	V	3.1	3.7	3.7	3.7	3.1	3.7	3.7	3.9	3.8	3.8	3.8	3.8	3.8	3.8	3.9	3.8	3.8
	S	3.7	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.7	3.1	3.7
	X	48	49	48	49	49	49	49	49	49	49	49	49	49	49	49	49	49
1.0	Q	22	27	31	35	39	45	48	53	57	61	65	70	75	80	85	89	93
	V	3.9	3.3	3.9	3.9	3.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	S	3.0	3.9	3.0	3.9	3.0	3.0	3.9	3.3	3.0	3.0	3.9	3.0	3.0	3.0	3.0	3.0	3.0
	X	52	52	52	52	53	53	93	53	53	53	53	53	53	53	53	53	53
1.1	Q	27	32	36	41	47	52	57	60	66	71	76	81	97	92	97	103	108
	V	4.0	4.1	4.1	4.1	4.1	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.3	4.3	4.3	4.3
	S	3.0	2.9	2.9	2.8	2.8	2.9	2.9	2.9	2.9	2.9	2.9	2.8	2.9	2.8	2.8	2.8	2.8
	X	55	55	56	56	57	57	57	57	57	57	57	57	57	57	57	57	57
1.[illegible]	Q	34	38	45	50	57	81	67	72	78	84	90	96	102	109	115	120	126
	V	4.2	4.3	4.3	4.3	4.3	4.3	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
	S	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.9	2.9	2.8	2.9	2.8	2.8	2.8	2.9
	X	60	60	60	60	60	60	60	60	61	61	61	61	61	61	61	61	61
1.[illegible]	Q	38	45	90	57	64	75	79	89	91	98	106	110	117	124	131	138	145
	V	4.4	4.4	4.4	4.5	4.5	4.5	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
	S	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	X	63	64	64	64	65	65	65	65	65	65	65	65	65	65	65	65	65
1.4	Q	43	51	58	66	75	81	89	95	102	109	117	125	133	140	147	156	163
	V	4.5	4.6	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8
	S	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	X	67	67	67	68	69	69	69	69	69	69	69	69	69	69	69	69	69
1.5	Q	50	58	67	74	84	93	100	110	118	125	134	143	152	160	170	175	183
	V	4.7	4.8	4.8	4.8	4.8	4.9	4.9	4.9	4.9	4.9	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	S	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	X	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72
1.6	Q	57	71	75	83	92	100	113	121	131	141	149	159	168	179	187	195	205
	V	4.9	4.9	5.0	5.0	5.0	5.0	5.0	5.1	5.1	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2
	S	2.6	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	X	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76
1.7	Q	63	75	85	95	106	115	124	133	144	155	164	175	183	196	204	215	225
	V	5.0	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
	S	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	X	80	80	80	80	80	80	81	81	81	81	81	81	81	81	81	81	81
1.8	Q	73	88	95	106	116	129	137	149	160	173	183	194	204	215	228	239	247
	V	5.1	5.2	5.2	5.3	5.3	5.3	5.3	5.4	5.4	5.4	5.4	5.4	5.5	5.5	5.5	5.5	5.5
	S	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	X	84	84	84	84	84	84	84	84	84	84	84	84	85	85	85	85	85
1.9	Q	80	92	104	114	128	141	152	165	176	188	200	213	223	236	248	262	271
	V	5.3	5.3	5.4	5.4	5.4	5.5	5.5	5.5	5.5	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
	S	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	X	87	87	88	88	88	88	88	88	88	88	88	89	89	89	89	89	89
2.0	Q	89	102	113	127	140	153	167	180	191	205	217	230	245	259	269	285	297
	V	5.4	5.5	5.5	5.5	5.6	5.6	5.6	5.6	5.7	5.7	5.7	5.7	5.7	5.8	5.8	5.8	5.8
	S	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	92	92	92	92	92	92	92	53	93	93	93	93	93	93	93	93	93
2.1	Q	96	112	125	140	154	168	186	195	207	223	238	253	266	280	296	311	325
	V	5.5	5.8	5.6	5.7	5.7	5.7	5.8	5.8	5.8	5.8	5.9	5.8	5.8	5.9	5.9	5.9	5.9
	S	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	95	95	95	95	95	95	95	96	98	96	92	97	97	98	98	98	98
2.2	Q	105	122	137	153	168	183	198	216	229	244	261	274	287	303	319	335	352
	V	5.6	5.7	5.7	5.8	5.8	5.9	5.9	5.9	6.0	6.0	6.0	6.0	6.0	6.0	6.1	6.1	6.1
	S	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	99	99	99	100	100	101	101	101	101	101	101	102	102	102	102	102	102
2.3	Q	119	134	149	166	183	200	215	232	247	266	282	297	312	330	343	361	378
	V	5.7	5.8	5.9	5.9	6.0	6.0	6.0	6.1	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.2	6.2
	S	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	X	104	105	105	105	105	105	106	106	106	106	106	106	106	106	106	106	106
2.4	Q	129	146	162	179	198	217	232	252	266	284	302	319	338	357	371	385	404
	V	5.9	6.0	6.0	6.1	6.1	6.2	6.2	6.2	6.2	6.2	6.3	6.3	6.3	6.3	6.3	6.3	6.3
	S	2.3	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	X	108	109	109	109	109	109	109	110	110	110	110	111	111	111	111	111	111

REFERENCE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

B-5.6

DESIGN DATA FOR EARTH SPILLWAYS

APRIL 1972
APPENDIX B-5

SIDE SLOPE 3:1
VEGETATED n=0.040

STAGE (Hp) IN FEET	SPILLWAY VARIABLES	BOTTOM WIDTH (b) IN FEET																
		8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
0.5	Q	7	8	9	10	12	14	14	16	17	18	20	21	22	24	25	27	28
	V	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	S	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.8	3.8	3.6	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	X	32	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
0.6	Q	8	11	12	14	16	19	20	22	24	26	27	29	30	33	35	36	38
	V	2.9	2.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	S	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	X	36	36	36	36	36	37	37	37	37	37	37	37	37	37	37	37	37
0.7	Q	11	14	16	19	21	24	26	29	31	33	36	38	41	43	45	48	48
	V	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
	S	3.5	3.5	3.9	3.5	3.5	3.5	3.9	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
	X	40	40	40	40	41	41	41	41	41	41	41	41	41	41	41	41	41
0.6	Q	14	17	20	23	26	30	32	35	38	42	45	47	50	52	55	59	60
	V	3.5	3.5	3.5	3.6	3.6	3.8	3.8	3.6	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	S	3.3	3.3	3.3	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
	X	44	44	44	44	45	45	45	45	45	45	45	45	45	45	45	45	45
0.9	Q	19	22	25	28	32	36	40	43	47	51	55	56	63	68	68	73	76
	V	3.7	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	S	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
	X	49	49	49	48	48	48	48	48	48	48	49	49	49	49	49	49	49
1.0	Q	20	27	30	35	38	43	48	52	56	61	64	69	74	79	82	86	90
	V	3.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	S	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	X	52	52	52	52	52	52	52	52	52	52	52	92	52	52	52	52	52
1.1	Q	25	31	34	40	45	48	54	60	65	76	74	79	84	90	95	100	105
	V	4.1	4.1	4.2	4.2	4.2	4.2	4.2	4.2	4.3	4.2	4.2	4.3	4.3	4.3	4.3	4.3	4.3
	S	2.9	2.9	2.8	2.9	2.9	2.9	2.8	2.9	2.9	2.8	2.8	2.8	2.6	2.8	2.9	2.8	2.8
	X	55	55	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
1.2	Q	30	37	42	47	52	59	65	71	76	82	88	92	99	105	110	116	122
	V	4.3	4.3	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	S	2.9	2.8	2.5	2.6	2.5	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.6	2.8
	X	59	59	60	60	60	60	60	60	60	60	80	60	60	60	60	60	60
1.3	Q	35	42	48	55	62	68	75	82	89	95	101	109	116	122	127	134	140
	V	4.5	4.5	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.7	4.7
	S	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	X	63	63	64	68	64	64	64	84	64	64	68	68	84	68	64	64	84
1.4	Q	40	48	56	64	70	78	86	93	100	108	114	121	130	138	146	152	159
	V	4.7	4.7	4.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.9	4.9	4.9	4.9
	S	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	3.8	3.8	3.8	2.6	2.6	2.6
	X	67	67	67	68	68	68	68	68	68	68	68	68	68	68	68	68	68
1.5	Q	46	54	63	71	82	88	96	106	113	121	128	136	144	154	164	173	180
	V	4.6	4.9	4.9	4.9	4.9	4.9	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.1
	S	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.5
	X	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72
1.6	Q	52	60	70	81	90	100	110	118	129	137	145	155	162	172	182	192	201
	V	4.9	5.0	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
	S	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	X	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76
1.8	Q	58	68	78	90	100	110	121	132	141	149	160	168	179	190	201	212	222
	V	5.0	5.2	5.2	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.4	5.4	5.4	5.4
	S	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	X	80	80	80	80	80	80	80	80	80	80	80	80	80	80	81	81	81
1.8	Q	65	76	88	100	110	122	133	145	155	166	175	188	196	208	220	232	243
	V	5.2	5.3	5.4	5.4	5.4	5.4	5.4	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
	S	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	X	83	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	85
1.9	Q	72	84	98	110	124	134	148	160	172	182	192	204	218	232	240	253	266
	V	5.4	5.4	5.5	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.7	5.7	5.7	5.7	5.7
	S	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	X	86	87	88	88	88	88	88	88	88	88	88	88	88	89	89	89	89
1.4	Q	79	94	107	120	133	148	160	172	186	197	212	223	236	252	265	276	288
	V	5.5	5.6	5.6	5.7	5.7	5.7	5.7	5.8	5.9	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
	S	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	90	92	92	92	92	92	92	92	92	92	92	92	92	93	93	93	93
1.4	Q	88	102	118	132	146	160	176	190	202	217	229	241	255	271	286	300	315
	V	5.6	5.7	5.8	5.8	5.8	5.9	5.9	5.9	5.5	5.9	5.9	5.9	6.0	6.0	6.0	6.0	6.0
	S	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.5	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	94	95	95	95	95	95	95	96	96	96	96	96	97	97	97	97	97
2.2	Q	95	112	128	143	158	176	192	204	220	234	246	263	280	297	313	328	340
	V	5.7	5.8	5.9	5.9	6.0	6.0	6.0	6.0	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
	S	2.4	2.4	2.4	2.5	2.5	2.5	2.3	2.3	2.3	2.3	2.3	2.7	2.3	2.7	2.3	2.3	2.3
	X	99	99	99	100	100	101	101	101	101	101	101	101	102	102	102	102	102
2.3	Q	104	120	138	155	172	190	205	222	236	251	266	283	299	319	336	354	367
	V	5.8	5.9	6.0	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.3	6.3	6.3
	S	2.4	2.4	2.3	2.3	2.5	2.3	2.3	2.5	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	X	103	104	104	105	105	105	106	106	106	106	106	106	106	106	106	106	106
2.4	Q	114	132	150	168	185	205	222	237	252	269	288	303	321	340	359	378	392
	V	6.0	6.0	6.1	6.2	6.2	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.4	6.4	6.4	6.4
	S	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	X	108	108	109	109	109	109	109	110	110	110	110	110	110	110	111	111	111

REFERENCE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

USDA, Soil Conservation Service
Columbus, Ohio

APPENDIX B-5

November 1971

SEDIMENT BASIN DESIGN DATA SHEET

Computed by________________ Date__________
Checked by_________________ Date__________

Project____
Basin #________ Location____
Total Drainage Area_____Acres. Total Disturbed Area_______Acres

SEDIMENT STORAGE DESIGN

1. Annual Sed.Vol.(Table 2) x Life of Structure=Design Sed.Storage
   __________________ac.ft. x _____________yrs.=____________ac.ft.
2. Excavate_____________cu.yd. to obtain required capacity.
   Elevation corresponding to scheduled time of clean out_______
   Distance below top of riser__________________________________

DESIGN DATA

Runoff

3. QT = _____cfs. Method Used__________________________________

Pipe Spillway (Q_{ps})

4. Min.pipe spillway capacity,Q_{ps}=0.21 x___D.A. Ac.=______cfs
5. Barrel: Dia._____inches; Length_____ft.; Fall_____ft.
6. Riser: Dia.______inches; Length_____ft.
7. Actual Discharge (B-5.2 or B-5.3)
   H = _______feet. h = ____________ft, Q_{ps} = __________cfs
8. No. of cutoff collars_____;Vertical Dim.___;Horizontal Dim._____

Emergency Spillway Flow Q_{es}

9. $Q_{es} = Q_T - Q_{ps}$ = ___________ - ______________ = _____________cfs

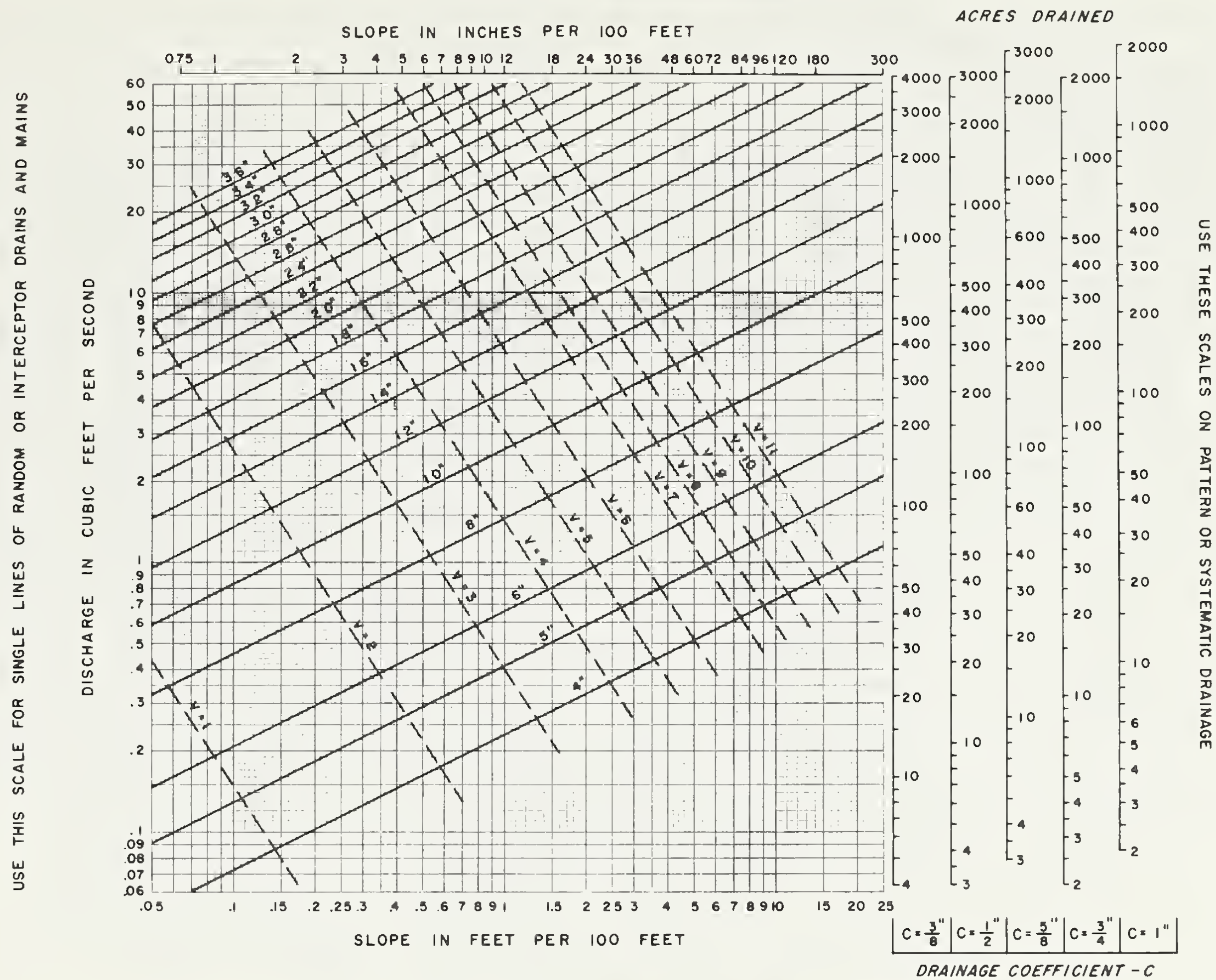
Emergency Spillway Design (B-5.6 or B-5.7)

10. Width_____ft. Hp_____ft. S_____% V_________________fps
    Entrance channel slope_____________%

DESIGN ELEVATIONS

11. Riser Crest = ___________ Design High Water = ___________
    Em. Spwy. Crest = ___________ Top of Dam = ___________

DRAIN CHART - CLAY, CONCRETE TILE AND BITUMINIZED FIBER PIPE



REFERENCE
DISCHARGE BASED ON:
$V = 138 R^{2/3} S^{1/2}$
PIPE FLOWING FULL, MANNING N = 0.011

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DRAIN CHART - CORRUGATED PLASTIC DRAIN TUBING

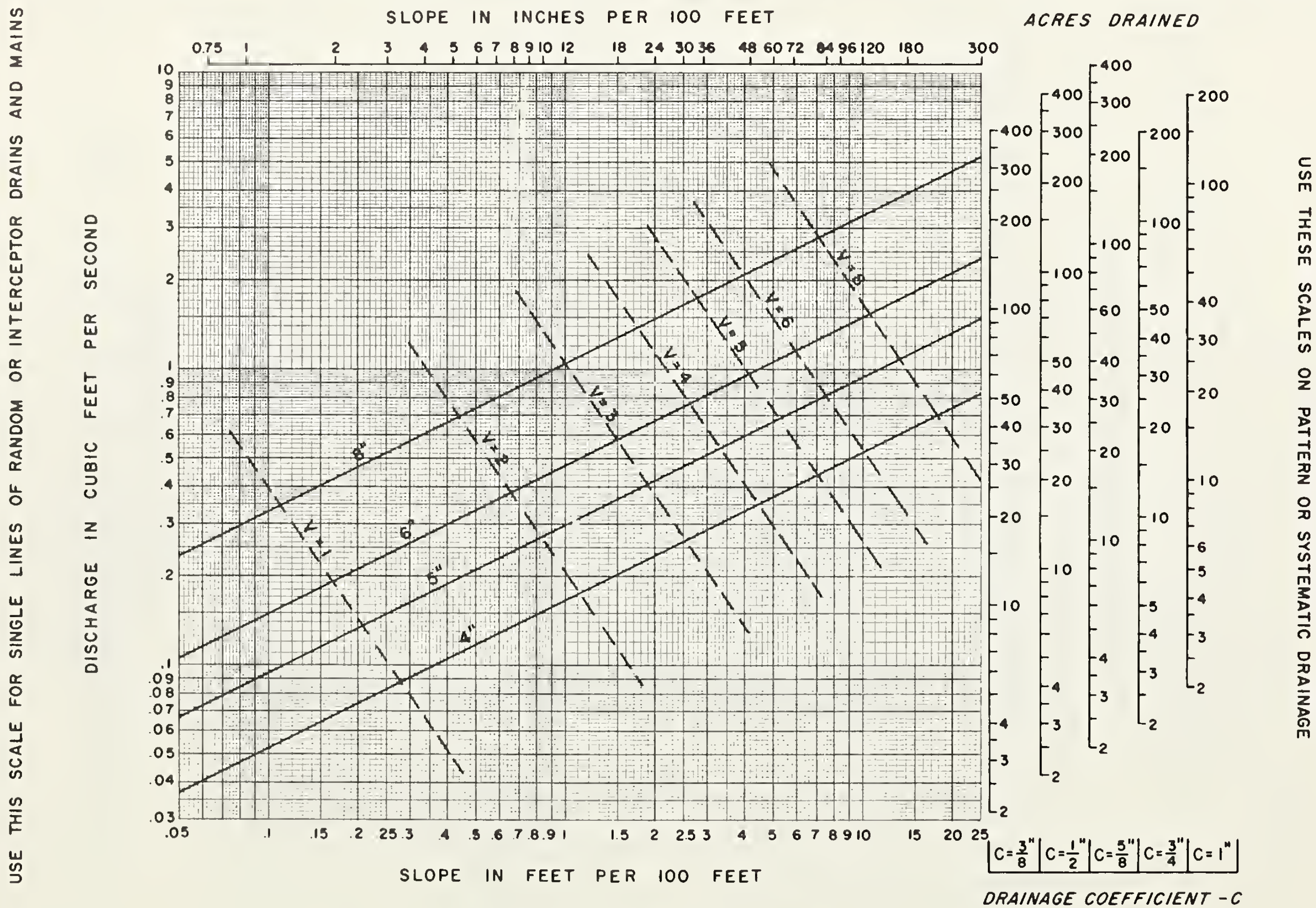


Exhibit 14-11.2

REFERENCE
DISCHARGE BASED ON:
$V = 99 R^{2/3} S^{1/2}$
PIPE FLOWING FULL, MANNING N=0.015

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DRAIN CAPACITY CHART - CORRUGATED METAL PIPE

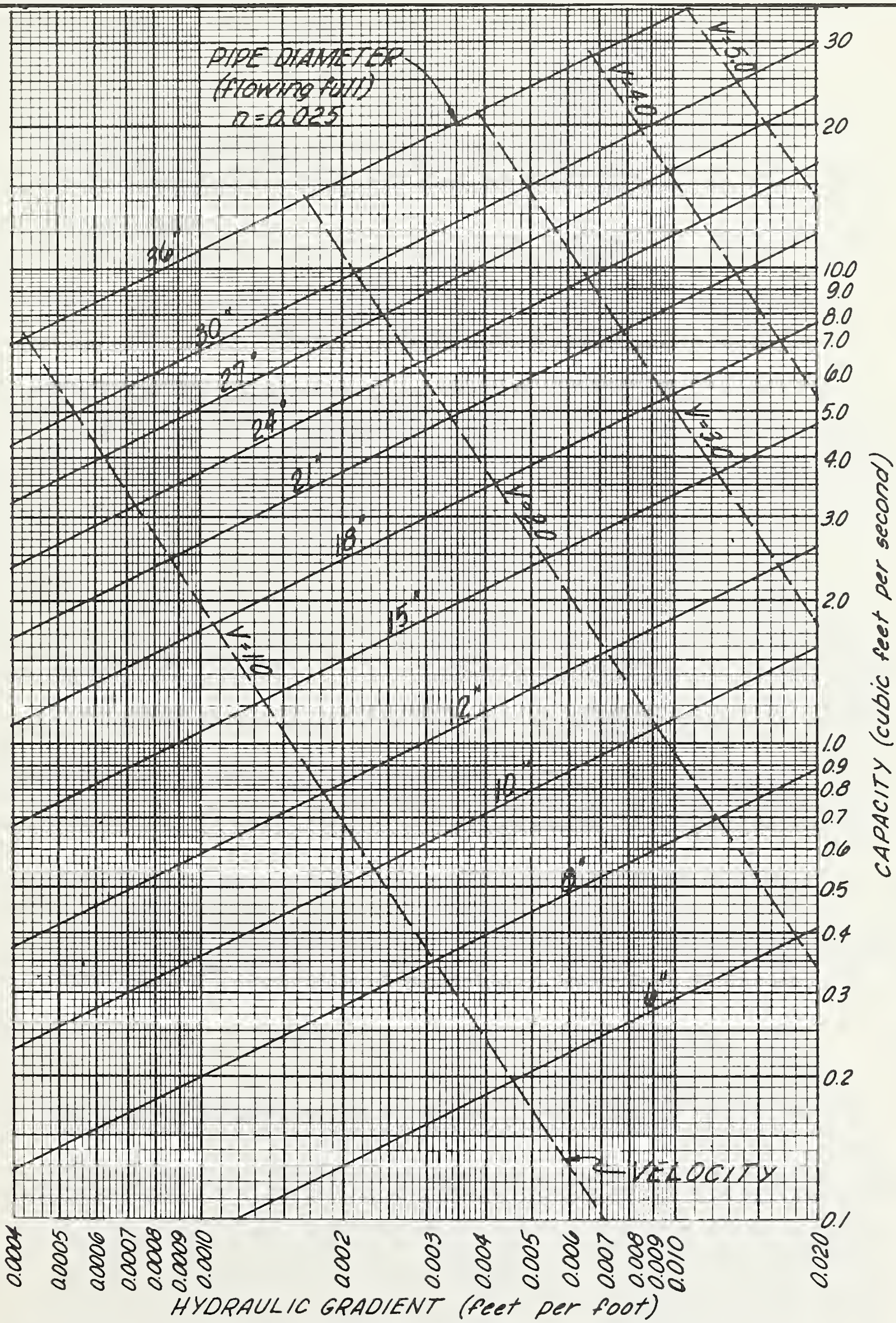
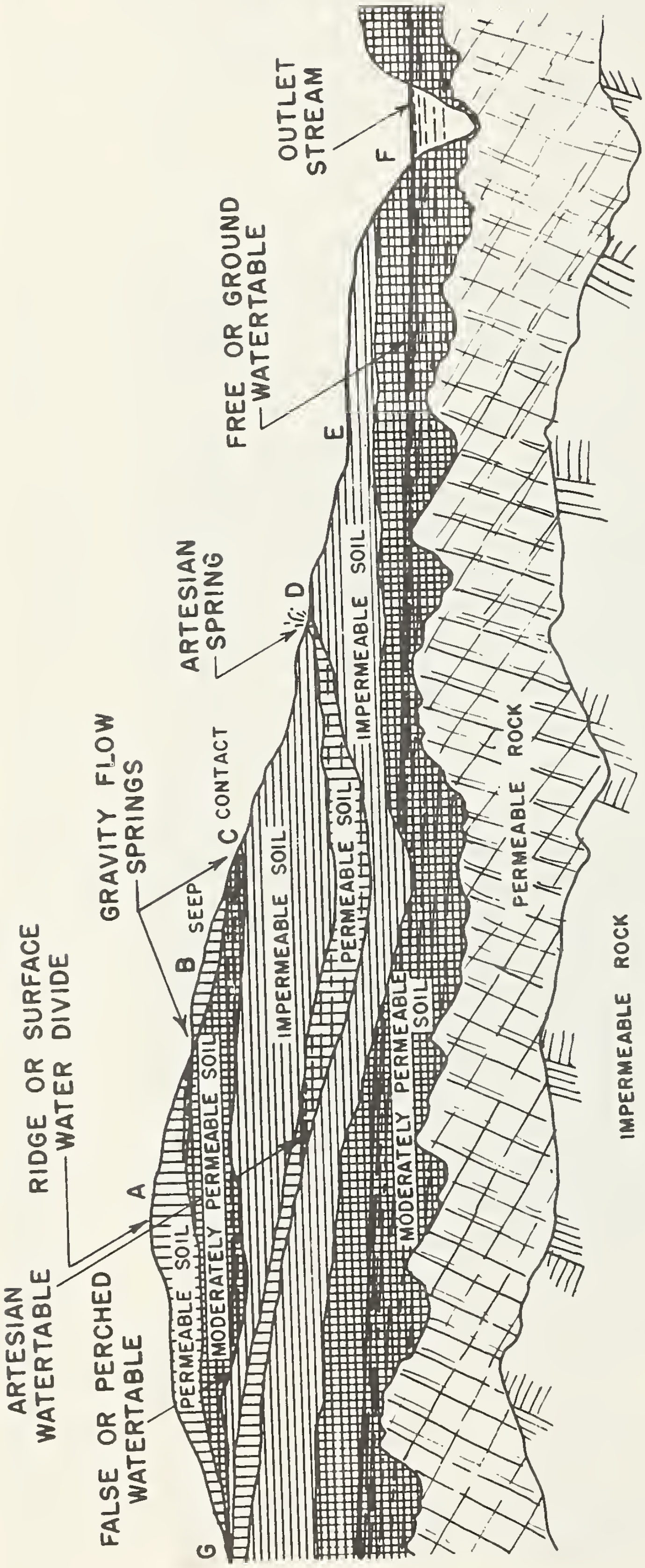
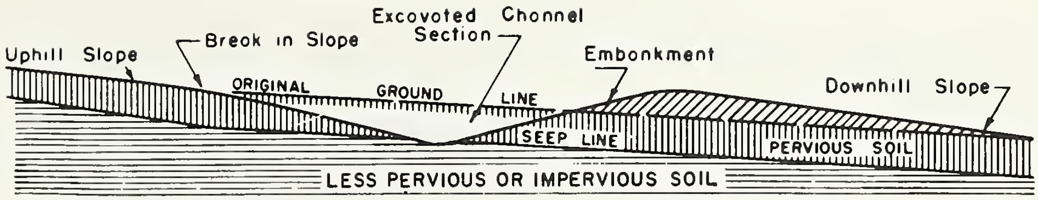


Exhibit 14-11.3

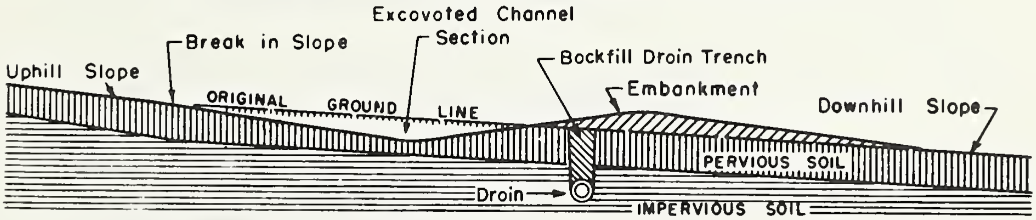
REFERENCE	U. S. DEPARTMENT OF AGRICULTURE	
DISCHARGE BASED ON $V = 59\ R^{2/3} S^{1/2}$ PIPE FLOWING FULL, MANNING N=0.025	SOIL CONSERVATION SERVICE	



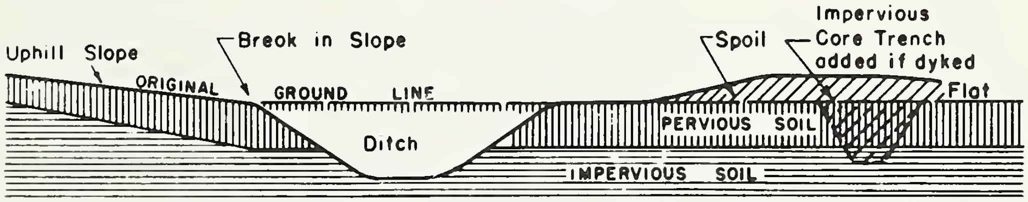
Ground water movement



A.- CROSS SECTION SHOWING DITCH AS SURFACE WATER DIVERSION AND SUB-SURFACE INTERCEPTOR ON SLOPE

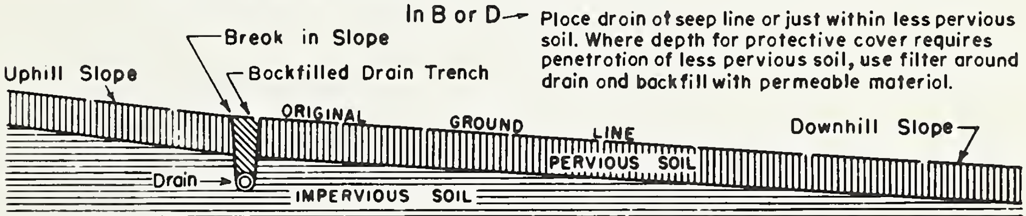


B.- CROSS SECTION SHOWING DITCH AS SURFACE WATER DIVERSION WITH DRAIN AS SUB-SURFACE INTERCEPTOR

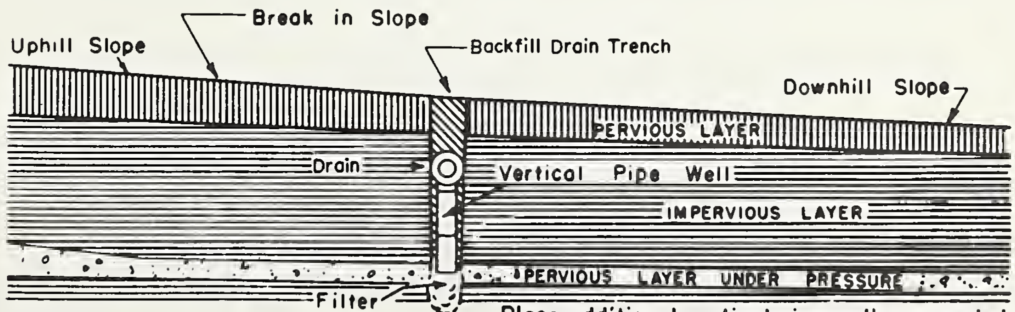


C-CROSS SECTION SHOWING DITCH AS SURFACE WATER DIVERSION AND SUB-SURFACE INTERCEPTOR FOR FLAT LAND

In B or D — Place drain at seep line or just within less pervious soil. Where depth for protective cover requires penetration of less pervious soil, use filter around drain and backfill with permeable material.



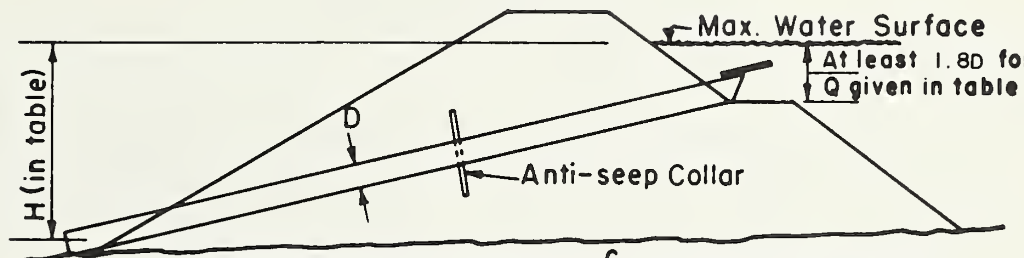
D.- CROSS SECTION SHOWING DRAIN AS SUB-SURFACE INTERCEPTOR



Place additional vertical pipe wells as needed to one side of drain and join with filter material used as backfill.

E.- CROSS SECTION SHOWING RELIEF WELL AND INTERCEPTOR DRAIN

Typical interceptor installations



CROSS SECTION OF DAM ON ℄ OF PIPE SPILLWAY

CAPACITY TABLE OF HOODED INLET IN C.F.S. FOR VARYING HEADS						
Head	8" DIAMETER PIPE For Pipe Lengths of:			12" DIAMETER PIPE For Pipe Lengths of:		
H	50'	70'	90'	50'	70'	90'
5	1.8	1.6	1.4	5.0	4.4	4.0
6	2.0	1.7	1.5	5.5	4.8	4.4
7	2.1	1.9	1.7	6.0	5.2	4.7
8	2.3	2.0	1.8	6.3	5.6	5.0
9	2.4	2.1	1.9	6.7	5.9	5.4
10	2.6	2.2	2.0	7.1	6.2	5.6
11	2.7	2.3	2.1	7.4	6.5	5.9
12	2.8	2.4	2.2	7.8	6.8	6.2
13	2.9	2.5	2.3	8.1	7.1	6.4
14	3.0	2.6	2.3	8.4	7.4	6.7
15	3.1	2.7	2.4	8.7	7.6	6.9
16	3.2	2.8	2.5	9.0	7.9	7.1
17	3.3	2.9	2.6	9.2	8.1	7.3
18	3.4	3.0	2.7	9.5	8.4	7.6
19	3.5	3.0	2.7	9.8	8.6	7.8
20	3.6	3.1	3.0	10.0	8.8	8.0

Capacity chart for 8- and 12-inch C.M. pipe hood inlet spillway

The use of some type of device to prevent vortex formation is necessary for developing maximum capacity shown in the previously mentioned figures.

PIPE FLOW CHART (Full flow assumed)

For Hooded Inlet K_e = 1.08 and 70 feet of Corrugated Metal Pipe Conduit, n = 0.025.
Note corrections for other pipe lengths.

Dia. / H	12"	15"	18"	21"	24"	30"	36"	42"
2	2.79	4.89	7.72	11.16	15.48	26.31	40.28	57.42
3	3.41	5.99	9.46	13.67	18.97	32.32	49.34	70.34
4	3.94	6.92	10.92	15.78	21.90	37.32	56.98	81.22
5	4.40	7.74	12.21	17.64	24.48	41.72	63.70	90.80
6	4.82	8.47	13.37	19.32	26.82	45.70	69.77	99.45
7	5.21	9.16	14.45	20.88	28.97	49.37	75.38	107.45
8	5.57	9.78	15.44	22.31	30.97	52.77	80.57	114.85
9	5.91	10.38	16.38	23.61	32.85	55.98	85.47	121.83
10	6.23	10.94	17.26	24.95	34.62	59.00	90.09	128.41
11	6.53	11.48	18.11	26.17	36.32	61.90	94.50	134.70
12	6.82	11.99	18.91	27.33	37.93	64.64	98.69	140.67
13	7.10	12.48	19.69	28.45	39.49	67.29	102.73	146.44
14	7.37	12.95	20.43	29.52	40.97	69.83	106.61	151.96
15	7.63	13.40	21.15	30.56	42.41	72.27	110.34	157.28
16	7.88	13.84	21.84	31.56	43.80	74.64	113.96	162.44
17	8.12	14.27	22.51	32.53	45.15	76.94	117.46	167.44
18	8.36	14.68	23.17	33.48	46.46	79.17	120.88	172.31
19	8.59	15.08	23.80	34.39	47.73	81.34	124.19	177.02
20	8.81	15.47	24.42	35.28	48.97	83.45	127.41	181.61
21	9.03	15.86	25.02	36.16	50.18	85.52	130.57	186.12
22	9.24	16.23	25.61	37.00	51.36	87.52	133.62	190.46
23	9.45	16.59	26.19	37.84	52.52	89.49	136.64	194.77
24	9.65	16.95	26.69	38.65	53.64	91.42	139.57	198.95
25	9.85	17.30	27.30	39.45	54.75	93.30	142.45	203.05
L	Correction Factors For Other Lengths							
40	1.23	1.21	1.19	1.18	1.16	1.13	1.12	1.10
50	1.14	1.13	1.12	1.11	1.10	1.09	1.08	1.07
60	1.06	1.06	1.05	1.05	1.04	1.04	1.04	1.03
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	0.95	0.95	0.95	0.96	0.96	0.96	0.97	0.97
90	0.90	0.91	0.91	0.92	0.92	0.93	0.94	0.94
100	0.86	0.87	0.88	0.89	0.89	0.90	0.91	0.92

Pipe flow chart for corrugated
metal pipe hood inlet spillway

PIPE FLOW CHART (Full flow assumed)

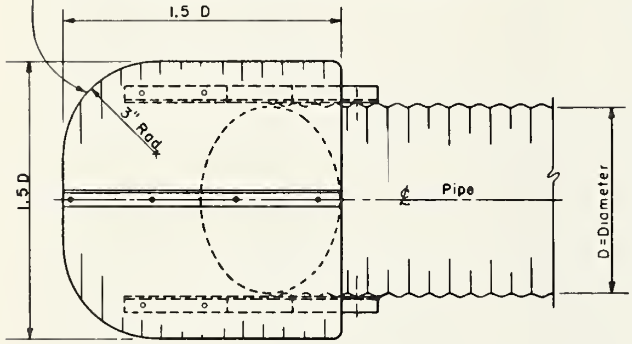
For Hooded Inlet K_e = 1.08 and 70 feet of smooth pipe conduit, n = 0.010. Note corrections for other lengths.

H \ Dia.	10"	12"	14"	15"	18"	21"
2	3.20	4.85	6.85	7.99	11.92	16.64
3	3.92	5.94	8.38	9.79	14.60	20.39
4	4.53	6.85	9.68	11.31	16.86	23.54
5	5.06	7.66	10.82	12.64	18.85	26.32
6	5.54	8.39	11.86	13.84	20.64	28.83
7	5.99	9.07	12.81	14.96	22.30	31.15
8	6.40	9.69	13.69	15.99	23.84	33.29
9	6.79	10.28	14.52	16.96	25.29	35.31
10	7.16	10.84	15.31	17.87	26.65	37.22
11	7.51	11.36	16.05	18.74	27.95	39.03
12	7.83	11.87	16.77	19.58	29.20	40.77
13	8.16	12.36	17.46	20.41	30.39	42.45
14	8.47	12.82	18.11	21.15	31.54	44.05
15	8.77	13.27	18.75	21.89	32.64	45.59
16	9.06	13.71	19.36	22.61	33.72	47.08
17	9.33	14.13	19.96	23.31	34.75	48.53
18	9.61	14.54	20.54	29.99	35.76	49.94
19	9.87	14.94	21.10	24.64	36.74	51.31
20	10.12	15.33	21.65	25.28	37.69	52.64
21	10.38	15.71	22.19	25.91	38.63	53.95
22	10.62	16.07	22.70	26.51	39.53	55.21
23	10.86	16.44	23.24	27.11	40.42	56.45
24	11.09	16.79	23.72	27.69	41.29	57.67
25	11.32	17.14	24.21	28.26	42.14	58.86
L	Correction Factors for Other Lengths					
40	1.11	1.09	1.08	1.08	1.06	1.05
50	1.07	1.06	1.05	1.05	1.04	1.03
60	1.03	1.03	1.02	1.02	1.02	1.02
70	1.00	1.00	1.00	1.00	1.00	1.00
80	0.97	0.97	0.98	0.98	0.98	0.98
90	0.95	0.95	0.96	0.96	0.96	0.97
100	0.93	0.93	0.94	0.94	0.95	0.96

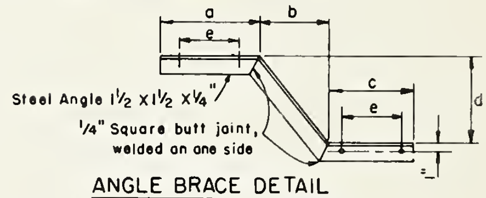
Pipe flow chart for smooth pipe hood inlet spillway

GAGE OF METAL BAFFLE AND DIMENSIONS OF ANGLE BRACE						
Diam. of Pipe D	Gage of Baffle	Angle Brace Dimensions in inches when used				
		a	b	c	d	e
6"	16					
8"	16					
10"	16					
12"	16	8	3 3/4	9	5	5 1/3
15"	16	9	4 7/8	9	6 1/2	5 1/3

Note: Angle Brace is optional

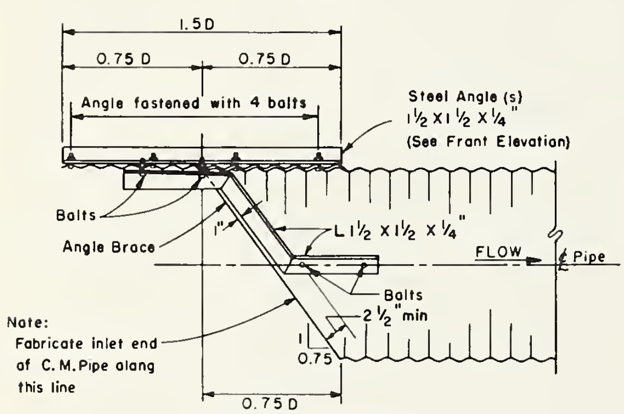


PLAN

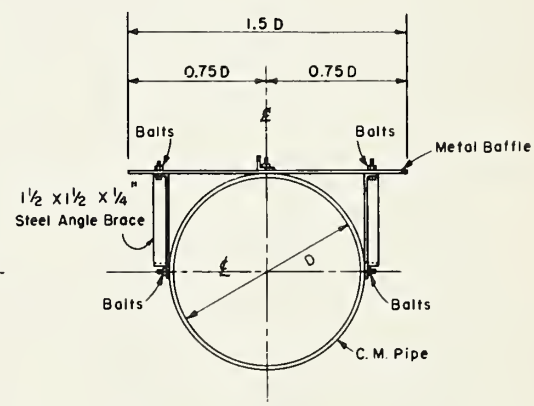


ANGLE BRACE DETAIL

(1 left and 1 right required for each baffle)



SIDE ELEVATION



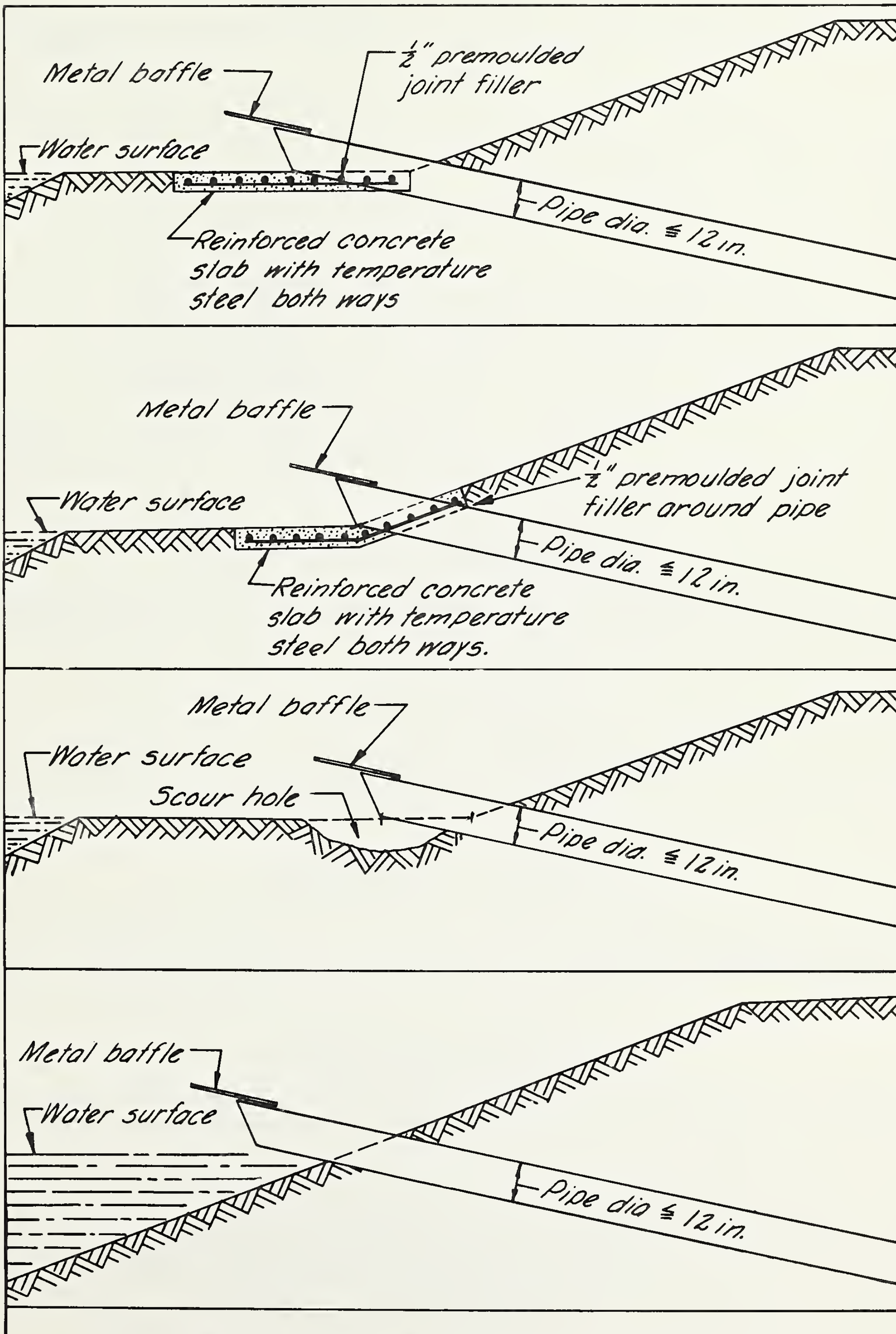
FRONT ELEVATION

Notes:

All bolts shall be 3/8" X 1 1/2" with nut and split washers
All holes for bolts shall be drilled 7/16" diameter.
All nuts, bolts and washers shall be galvanized, cadmium plated, or stainless steel.
All cuts shall be saw or shear cuts.
Holes in the angle brace shall be spaced and located to match corrugations in pipe and baffle.
Steel angles shall be galvanized.
All galvanizing damaged by cutting, drilling or welding shall be repaired by painting with two (2) coats of zinc dust-zinc oxide primer.

Details of a typical hood inlet and baffle for
6- to 15-inch diameter corrugated metal pipe

Under full pipe flow conditions, high velocities exist near the pipe entrance, which generally causes a scour hole in the embankment face unless protected by paving or riprap. It is, therefore, desirable to provide protection to prevent the formation of a scour hole under the inlet. Paving is better than riprap in that it prevents the growth of vegetation near the inlet.



Typical layouts of inlets for 12-inch or less hood inlet spillways

INSTRUCTIONS FOR INSTALLATION OF MULCH NETTINGS IN WATERWAYS

WHAT IT IS: Mulch netting is made of tightly twisted natural kraft paper yarns, woven with a warp count of one pair of yarns per two inches and a filling count of two per inch. It comes in rolls of 500 lineal yards and 45 inches wide.

WHY USED: Mulch netting is used to hold mulch in place over seeded areas in waterways until the sod is established. It also helps protect the soil from erosion during the critical period of vegetative establishment.

HOW USED: Use in place of sod.

PREPARING A WATERWAY CHANNEL

To prevent meandering, grade center to a parabolic shaped channel to confine low flows to the channel where nettings will be laid.

FERTILIZATION

Lime and fertilize to standard recommendations. Work lime and fertilizer into soil by disking.

SEEDING AND MULCHING

Immediately after lime and fertilizer have been applied prepare seedbed, seed, and mulch according to standard recommendations.

LAYING THE NETTING

Starting at the lower end of the channel, the mulch net shall be laid parallel to the flow of the water and as shown on the drawings.

The mulch net shall be secured in place by use of 0.120" diameter (#8 gauge) wire staples, 6 inch long minimum. Along butt joints and outside edges space staples at 4 foot intervals. In center of netting space staples at 6-foot intervals.

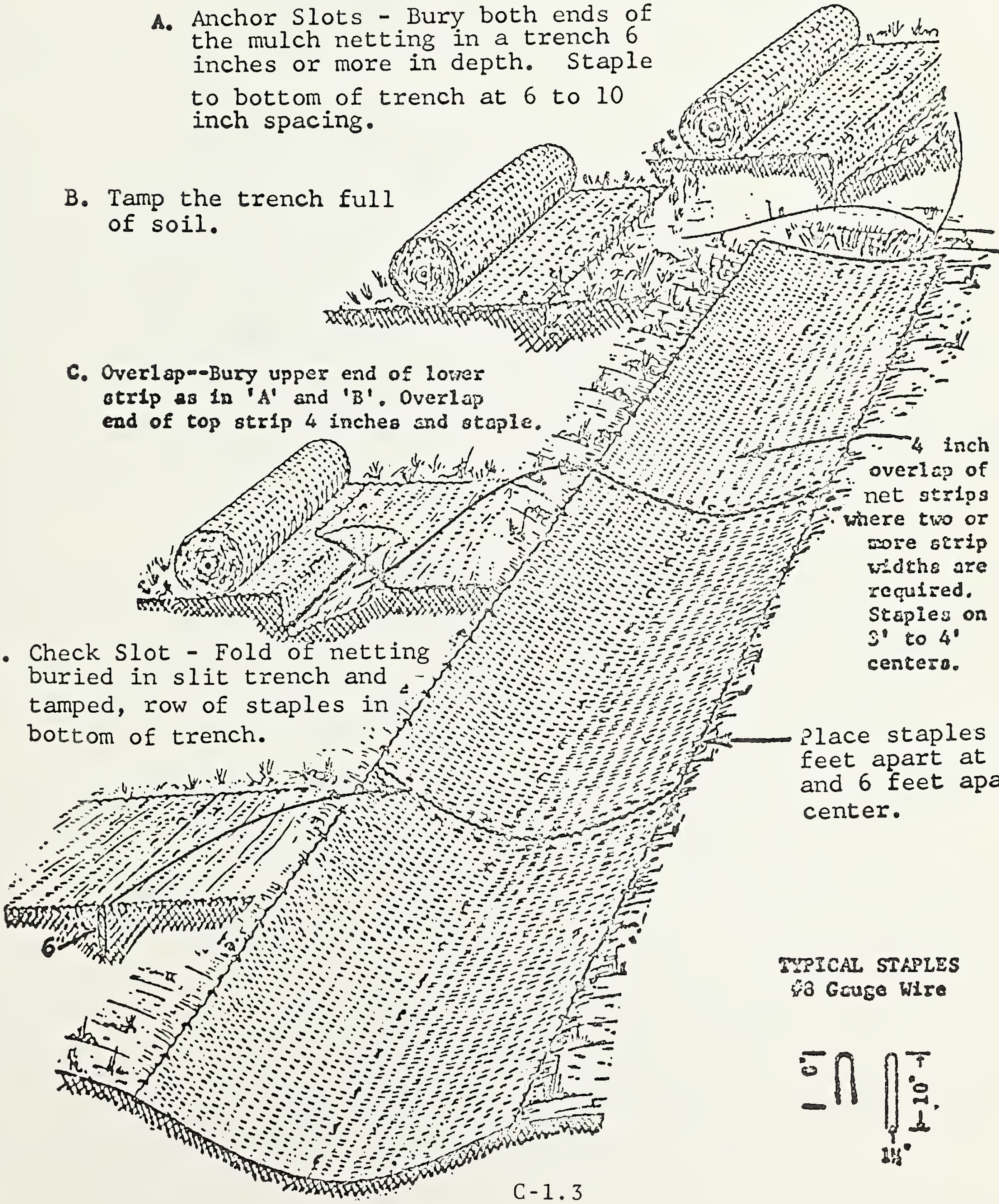
Anchor slots shall be used at both upstream and downstream ends of mulchnetting. Bury ends in a slit trench, at a minimum of 6 inches deep. Staple to bottom of trench at 6 to 10 inch spacing for added protection. Backfill trench and tamp firmly to conform to channel cross section.

Check slots shall be used whenever rills are likely to form. Such as long slopes where velocity and volume of water may be high, where grade change occurs, or at points of entry of concentrated flow, such as culverts or terraces. At points of entry into the waterway channel of these flows check slots shall be installed on outside edges of the mulch netting.

Check slots shall be installed similar to anchor slots and should extend beyond channel lines to prevent rills that might form outside the channel lining. Spacing of check slots will vary from 25 feet to 100 feet, depending upon erodibility of the soil.

(Do not walk or travel on mulch netting with men or equipment after placement.)

DETAIL FOR STABILIZING WATERWAYS WITH MULCH NETTING



A. Anchor Slots - Bury both ends of the mulch netting in a trench 6 inches or more in depth. Staple to bottom of trench at 6 to 10 inch spacing.

B. Tamp the trench full of soil.

C. Overlap--Bury upper end of lower strip as in 'A' and 'B'. Overlap end of top strip 4 inches and staple.

D. Check Slot - Fold of netting buried in slit trench and tamped, row of staples in bottom of trench.

4 inch overlap of net strips where two or more strip widths are required. Staples on 3' to 4' centers.

Place staples 4 feet apart at edge and 6 feet apart in center.

TYPICAL STAPLES
#8 Gauge Wire

GUIDELINES FOR PROTECTING TREES AGAINST DAMAGE FROM CONSTRUCTION WORK

Saving trees during and after construction has many advantages. These include aesthetic values, beautification, soil erosion control, shade, wildlife enhancement, screening and breaking the forces of wind. These factors are important in considering appropriate locations of trees to be protected.

Other evaluations need to be made in deciding which trees to save. These are species, size, age, vigor, cost, work involved. in preserving trees, and adaptation of trees to environmental changes. Tree species vary in their characteristics and this must be considered carefully in selecting trees to be saved. Maples, linden, dogwood and most conifers are shallow rooted and may hinder the desirable growth of lawns and certain ornamental shrubs. Willows and some poplars may clog tile or sewer lines. Some trees are more susceptible than others to insects and diseases. Elm, poplar, willow and locust adapt more easily to environmental changes. Less adaptable trees are beech, birch, hickory, tulip tree, some oaks, most maples and most conifers. Old or large trees do not adapt to environmental changes as well as young trees of the same species. A factor to consider in saving trees is that young trees may be replaced cheaper than it costs to preserve them.

Trees need to be protected from construction equipment and supplies, grade changes--either higher or lower--and excavations for utility lines. To protect a tree against mechanical injury, construct a simple fence or other barrier around it. Enclose an area at least 10 feet square with the tree in the center. All exposed roots should be inside the barrier to prevent damage from vehicles and construction equipment.

Tree roots need air, water, and minerals to survive. Any changes in grade will affect these important ingredients, and a tree has difficulty in obtaining normal amounts of each. In raising grades, minor fills--6 inches or less in depth--may not do any harm if soil is fertile and has good tilth. Major grade increases usually require gravel layers and tile drain systems (See figure C-2.1). Tiles are laid on original grade in the form of spokes of a wheel. The "spokes" open into a dry well built around the tree trunk. The dry well acts as the hub of the tile system and holds fill away from the tree trunk. It may be necessary to place a series of bell tiles vertically over the roots and connected to the rim of the wagon-wheel system to allow for additional air and water circulation. The air system will have to be designed for each tree individually, and it will have to fit the contour of the land so water drains away from the tree trunk.

Protecting a tree from a lowered grade is usually less complicated than protecting it from a raised grade. Generally, protection is achieved by terracing the grade. If space is available, the tree may be unharmed by letting it remain on a gently sloping mound. Another way to protect it from a lowered grade is to build a retaining wall between it and the lower grade (See Figure C-2.2).

Trees can be protected from underground utility lines. If the route cannot be diverted around the tree, tunneling under it may be necessary (See Figure C-2.3). In tunneling, cut as few roots as possible, cut them clearly, paint cut root ends with a wound dressing like asphalt-base paints, and back fill trench as soon as possible to keep roots from being exposed to air.

There may be occasions when the only way to save a tree is to move it. It is best to move trees when they are dormant. Practically no kind of plant can survive if roots have dried out. Roots must be moist at all times. Trees are moved either by the bare-root method or by the balled and burlapped (B&B) method. Bare-rooted trees may be moved if they are small and dormant, and protected. They should be protected by applying wet material such as peat moss to their roots immediately and kept moist. In the B&B method, balls of earth should enclose most of the root system. Tables C-2.1 and C-2.2 give recommended minimum ball diameters and depths of holes for different ball sizes of shrubs and trees.

A more complete discussion of this subject appears in Agricultural Information Bulletin 285, "Protecting Trees Against Damage from Construction Work."

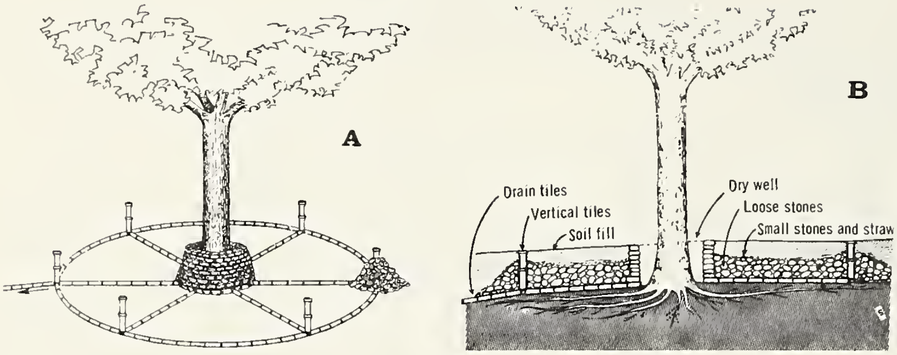
Table C-2.1 - Recommended Minimum Ball Diameter for Different Sizes of Shrubs and Trees

Shrubs and Small Trees		Larger Trees	
Height of Plant (ft.)	Diameter of Ball (in.)	Tree Diameter 1 Foot Above Ground (in.)	Diameter of Ball (in.)
1 1.2 - 2	11	1 1/4 - 1 1/2	18
2 - 3	12	1 1/2 - 1 3/4	20
3 - 4	14	1 3/4 - 2	22
4 - 5	16	2 - 2 1/2	24
5 - 6	18	2 1/2 - 3	28
6 - 7	20	3 - 3 1/2	33
7 - 8	22	3 1/2 - 4	38
8 - 9	24	4 - 4 1/2	43
9 - 10	26	4 1/2 - 5	48
10 - 12	29	5 - 5 1/2	53
12 - 14	32	5 1/2 - 6	58
14 - 16	36	6 - 7	65

Table C-2.2 - Recommended Depths to Dig for Different Ball Sizes

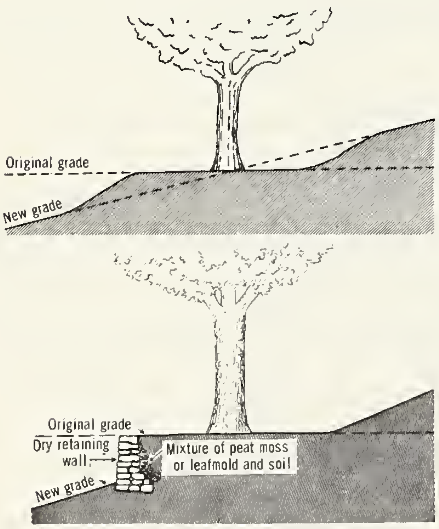
Depth of Ball (Inches)	Diameter of Ball (Inches)
10	8
20	15
30	20
48	30

Figure C-2.1



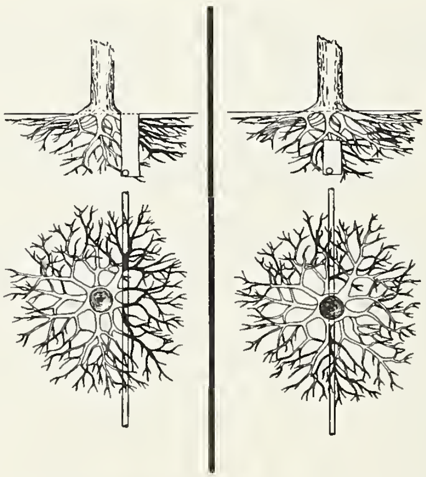
A tile system protects a tree from a raised grade. ***A,*** **The tile is laid out on the original grade, leading from a dry well around the tree trunk.** ***B,*** **The tile system is covered with small stones to allow air to circulate over the root area.**

Figure C-2.2



A retaining wall protects a tree from a lowered grade.

Figure C-2.3



Tunnel beneath root systems. Drawings at left show trenching that would probably kill the tree. Drawings at right show how tunneling under the tree will preserve many of the important, feeder roots.

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